INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

<table>
<tr><td>Department</td><td colspan="5">ELECTRONICS AND ELECTRICAL ENGINEERING</td></tr>
<tr><td>Course Name</td><td colspan="5">Linear algebra and Ordinary differential equations</td></tr>
<tr><td>Course Code</td><td colspan="5">AHS002</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td colspan="5">I</td></tr>
<tr><td>Course Type</td><td colspan="5">Foundation</td></tr>
<tr><td>Regulation</td><td colspan="5">IARE -R16</td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>3</td><td>1</td><td>4</td><td>-</td><td>-</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Ms. L Indira, Associate Professor</td></tr>
</table>

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	10+2	-	

II COURSE OVERVIEW:

The Linear algebra is a sub-field of mathematics concerned with vectors, matrices, and linear transforms. Calculus is the branch of mathematics which majorly deals with derivatives and integrals. Linear algebra is a key foundation to the field of machine learning. The course includes types of Matrices, Rank, methods of finding rank, Eigen values and Eigen vectors, maxima and minima of functions of several variables, solutions of higher order ordinary differential equations and Fourier series. Matrices are used in computer animations, color image processing. Eigen values are used by engineers to discover new and better designs for the future. The laws of physics are generally written down as differential equations. So, differential equations have wide applications in various engineering and science disciplines. This course enables the students to gain basic knowledge on the mathematics which is used in modeling the real time engineering problems very often.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Liner algebra and calculus	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
30 %	Understand
60 %	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

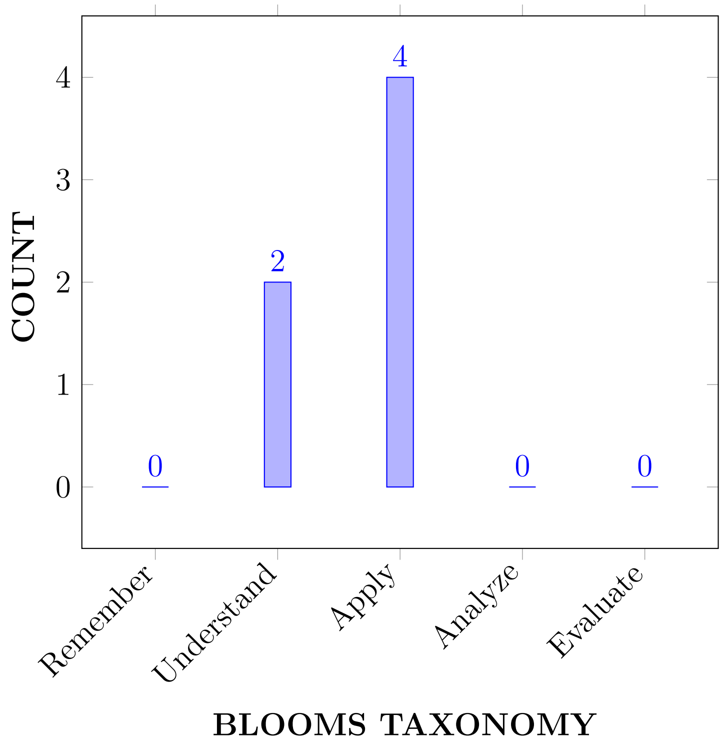
I	The principles of Eigen value analysis and linear transformations, Matrix rank finding methods.
II	The analytical methods for solving higher order differential equations with constant coefficients.
III	The calculus of functions of several variables and the concept of maxima-minima for a three-dimensional surface

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Calculate** the rank and inverse of real and complex matrices with elementary transformation methods.	Apply
CO 2	**Compute** the diagonally equivalent matrix and Cayley Hamiltonion equation of the given matrix by using Eigen values and Eigen vectors.	Apply
CO 3	**Interpret** the properties of differential equation of first order and first degree and orthogonal trajectories byusing integration factor method	Understand
CO 4	**Solve** the Second and higher order linear homogeneous and non homogeneous differential equations with constant coefficients by using substitution method.	Apply
CO 5	**Interpret** the extreme values for functions of several variables by using parial derivatives .	Understand
CO 6	**Apply** mean–value theorems in establishing some mathematical inequalities	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/SEE/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/SEE/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Analyze, design, investigate, simulate and/or fabricate/commission the electrical systems involving generation, transmission, distribution and utilization of electrical energy.	-	-
PSO 2	Focus on the components of power system, its analysis, operation, control and protection; electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and academia.	-	-
PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer.	-	CIE/SEE/AAT

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-		-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	✓
CO 5	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	- -
CO 6	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Explain the role of rank and inverse of real and complex matrices in solving complex engineering problems by using elementary transformation methods (**principles of mathematics** and **scientific methodology**). Eigen vectors (**principles of mathematics** and **scientific methodology**)).	2
CO 2	PO 1	Determine the diagonally equivalent matrix of given matrix involved in the complex engineering problems modeled by matrices with help of Eigen values and Eigen vectors (**principles of mathematics** and **scientific methodology**)).	2
	PO 2	Understand the **statement** and **formulation** of a complex engineering problem **modeled** by matrices with help of Eigen values and Eigen vectors and diagonalization to **develop** the solution and reaching substantiated conclusions by the **interpretation of results**	5
CO 3	PO 1	Identify whether the given differential equation of first order and first degree is exact or not by using integration factor method (**principles of mathematics** and **scientific methodology**)	2
CO 4	PO 1	Solve the complex engineering problems modeled by Second and higher order linear homogeneous differential equations (principles of mathematics) with constant coefficients by using substitution method (**principles of mathematics** and **scientific methodology**)	2
	PO 2	Understand the **statement** and **formulation** of a complex engineering problem **Modeled** by linear differential equations and solve them using substitution method along with basic principles of mathematics to **develop** the solution and reaching substantiated conclusions by the **interpretation of results** .	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 3	**Model, operate and control** the electricalflow in LCR circutes using Linear differentail equations in support with Kirchoff's law of voltage and **Solve** the differential equations by using substitution methodand method of variation of parametrs	1
CO 5	PO 1	Explain the mean–value theorems for the single variable functions and apply them in the complex engineering problems modeled by functions of single variables with their geometrical interpretation (**principles of mathematics** and **scientific methodology**).	2
CO 6	PO 1	Interpret the extreme values for functions of several variables and apply them in the complex engineering problems modeled by functions of several variableswith the help of partial derivatives (**principles of mathematics** and **scientific methodology**).	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	5	-	-	-	-	-	-	-	-	-	-	-	-	1
CO 5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	67	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	67	50	-	-	-	-	-	-	-	-	-	-	-	-	14
CO 5	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 6	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 - $5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	-	-	1
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	4	-	-	-	-	-	-	-	-	-	-	-	-	1
AVERAGE	3	2	-	-	-	-	-	-	-	-	-	-	-	-	1

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	PO1,PO2	SEE Exams	PO1,PO2	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5Tech-talk	PO1,PO2	Open Ended Experiments	-
Assignments		concept video		mini project	

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**THEORY OF MATRICES**
	Real matrices: Symmetric, skew-symmetric and orthogonal matrices; Complex matrices: Hermitian, Skew- Hermitian and unitary matrices; Elementary row and column transformations, elementary matrix, finding rank of a matrix by reducing to Echelon form and normal form; Finding the inverse of a matrix using elementary row/column transformations: Gauss-Jordan method; Solving of linear system of equations by LU decomposition method.
MODULE II	**LINEAR TRANSFORMATIONS**

	Cayley-Hamilton theorem: Statement, verification, finding inverse and powers of a matrix; Linear dependence and independence of vectors; Linear transformation; Eigen values and Eigen vectors of a matrix; Properties of Eigen values and Eigen vectors of real and complex matrices; Diagonalization of matrix.
MODULE III	**DIFFERENTIAL EQUATIONS OF FIRST ORDER AND THEIR APPLICATIONS**
	Solution of first order linear differential equations by exact, non exact, linear equations; Bernoulli equation. Applications of first order differential equations: Orthogonal trajectories; Newton's law of cooling; Law of natural growth and decay.
MODULE IV	**HIGHER ORDER LINEAR DIFFERENTIAL EQUATIONS AND THEIR APPLICATIONS**
	Linear differential equations of second and higher order with constant coefficients, non-homogeneous term of the f(x)=e^{ax},sinax,cosaxand f (x) $= x^n$, $e^{ax}v(x)$, $x^n v(x)$; Method of variation of parameter; Application to electrical circuits and Simple Harmonic Motion
MODULE V	**FUNCTIONS OF SINGLE AND SEVERAL VARIABLES**
	Mean value theorems: Rolle's theorem, Lagrange's theorem, Cauchy's theorem-without proof; Functions of several variables: Partial differentiation, chain rule, total derivative, Euler's theorem, functional dependence, Jacobian, maxima and minima of functions of two variables without constraints and with constraints; Method of Lagrange multipliers

TEXTBOOKS

1. Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons Publishers, 9th Edition,2014. .

2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 42nd Edition,2012.

REFERENCE BOOKS:

1. RK Jain & SRK Iyengar, "Advanced Engineering Mathematics", Narosa Publishers, 5th Edition,2016

2. Ravish R Singh, Mukul Bhatt, "Engineering Mathematics-1", Tata McGraw Hill Education, 1st Edition, 2009..

3. Srimanthapa & SubothC.Bhunia,"EngineeringMathematics", Oxford Publishers, 3rd Edition ,2015

WEB REFERENCES:

1. https://nptel.ac.in/courses/111/108/111108157

COURSE WEB PAGE:

1. lms.iare.ac.in

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
	OBE DISCUSSION		

1	Introduction to outcome based education		
CONTENT DELIVERY (THEORY)			
2	Theory of matrices: types of real matrices	CO1	T2:32.1R1:4.1 1
3	Real matrices:symmetric, skew-symmetric matrices	CO1	T2:32.1 R1:4.2
4	Real Matrices: orthogonal matrices	CO1	T2:32.1 R1:4.3
5	Complex matrices:Hermitian, Skew- Hermitian	CO1	T2:32.1 R1:4.3
6	Complex matrices: unitary matrices	CO1	T2:32.5 R1:4.6
7	Elementary row and column transformations	CO1	T2:32.5 R1:4.6
8	Rank of a matrix by echelon form	CO1	T2:32.4 R1:4.5
9	Rank of a matrix by normal form	CO1	T2:32.7 R1:4.8
10	Inverse of a matrix by Gauss-Jordan method	CO1	T2-7.1 R1:7.4
11	Eigen values of a matrix	CO2	T2-7.1 R1:7.4
12	Eigen vectors of a matrix	CO2	T2-7.1 R1:7.4
13	Diagonalizationof matrix by linear transformation.	CO 2	T2:7.1 R1:7.4
14	Cayley-Hamilton theorem- statement, verifications	CO 2	T2:7.1 R1:7.4
15	Applications of Cayley – Hamilton theorem	CO 2	T3-2.9 R1:2.1
16	Linear dependence and independence of vectors	CO 2	T3-2.5 R1:2.8
17	First order linear differential equations	CO3	T3-2.5 R1:2.8
18	Bernoulli's differential equations	CO3	T3-2.5 R1:2.8
19	Exact differential equations	CO3	T3-2.5 R1:2.8
20	Non exact differential equations	CO3	T3-2.5 R1:2.8
21	Equations reducible to exact form	CO3	T3-2.61 R1:2.10
22	Orthogonal trajectories	CO3	T1-7.1 R2:7.5
23	Newton's law of cooling	CO3	T3-2.61 R1:2.10
24	Law of natural growth and decay	CO3	T1-7.1 R2:7.6
25	Application method of Lagrange multipliers	CO3	T1-7.1 R2:7.7
26	Method of Lagrange multipliers	CO3	T3-2.5 R1:2.8
27	higher order Linear differential equations	CO4	T3-2.5 R1:2.8
28	Linear differential equations of second and higher order with polynomial coefficients	CO4	T3-2.5 R1:2.8
29	Non-homogeneous term of the type f (x) $=e^{ax}$	CO4	T3-2.5 R1:2.8
30	Q(x) is of the type f(x) = sinax or cosax	CO4	T2-7.1 R1:7.4
31	Non-homogeneous term of the type f (x) = X^n	CO4	T2:7.1 R1:7.4
32	Non-homogeneous term of the type f (x) = $e^{ax}V(x)$	CO4	T2:7.1 R1:7.4
33	Method of variation of parameters	CO4	T3-2.9 R1:2.1
34	Mean value theorems:1. Rolle's theorem	CO5,CO 6	T3-2.5 R1:2.8
35	Mean value theorems:2. Lagrange's theorem	CO5,CO 6	T3-2.5 R1:2.8
36	Mean value theorems:3. Cauchy's theorem	CO5,CO 6	T2:7.1 R1:7.4
37	Functions of several variables: Partial differentiation	CO5,CO 6	T3-2.9 R1:2.1
38	Jacobian transformations	CO5,CO 6	T3-2.5 R1:2.8
39	Functional dependence	CO5,CO 6	T2:7.1R1:7.4
40	Maxima and minima of functions with two variables	CO5,CO 6	T3-2.9 R1:2.1
41	Maxima and minima of functions with three variables	CO5,CO 6	T3-2.5R1:2.8

PROBLEM SOLVING/ CASE STUDIES			
42	Rank of the matrix by Echelon and normal form	CO1	T2:32.1 R1:4.2
43	Solving system of linear non homogeneous equations	CO1	T2:32.1 R1:4.3
44	Eigen values and eigen vectors of the matrix	CO2	T2:32.1 R1:4.3
45	Finding spectral matrix by linear transformation.	CO2	T2-7.1 R1:7.4
46	Verification of Caley- Hamilton theorem	CO2	T2-7.1 R1:7.4
47	Finding powers of the matrix by Caley -Hamilton theorem	CO2	T2:7.1 R1:7.4
48	Solving first order differential equations	CO3	T2:7.1 R1:7.4
49	Solving Non-Homogeneous Differential Equations.	CO3	T3-2.5 R1:2.8
50	Solving linear and exact differential equations	CO3	T3-2.5 R1:2.8
51	Finding C.F and P.I. of higher order differential equations	CO9	T3-2.5 R1:2.8
52	Solving Second Order Non-homogeneous differential equations by method of variation of parameters	CO4	T3-2.5 R1:2.8
53	Solving higher differential equations of different types	CO4	T3-2.61 R1:2.10
54	Jacobian transformation in Cartesian and Polar Forms	CO 5,CO 6	T2:7.1 R1:7.4
55	Finding functional relationship.	CO 5,CO 6	T3-2.9 R1:2.1
56	Finding max.and min. of functions of two variables	CO 5,CO 6	T3-2.5 R1:2.8
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Real, complex matrices and rank of a matrix	CO1	T3-2.5 R1:2.8
58	Eigen values and eigen vectors, diagonalization	CO2	T3-2.5 R1:2.8
59	First order linear, exact and non-exact D.Es.	CO3	T3-2.5 R1:2.8
60	Higher order differential equations	CO4	T3-2.5 R1:2.8
61	Mean value theorems, Jacobian transformations, functionally dependent and independent	CO5	T3-2.61 R1:2.10
DISCUSSION OF QUESTION BANK			
62	Theory of matrices	CO1	T2:7.1R1:7.4
63	Linear transformations	CO2	T3-2.9R1:2.1
64	First order and degree differential equations	CO3	T3-2.5R1:2.8
65	Higher order differential equations	CO4	T2:32.1R1:4.3
66	Functions of several variables	CO5, CO 6	T2-7.1R1:7.4

Signature of Course Coordinator **HOD,EEE**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**COMPUTATIONAL MATHEMATICS AND INTEGRAL CALCULUS**				
Course Code	AHS003				
Program	B. Tech				
Semester	I				
Course Type	Foundation				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Ms. V Subbalaxmi, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
10+2	-	I	Basic Principles of complex functions

II COURSE OVERVIEW:

The course focuses on more advanced Engineering Mathematics topics which provide with the relevant mathematical tools required in the analysis of problems in engineering and scientific professions. The course includes Types of Interpolation, Curve fitting, Numerical solutions of Ordinary Differential Equations, Multiple Integrals, Vector Calculus and Special functions. The mathematical skills derived from this course form a necessary base to analytical and design concepts encountered in the program.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Computational Mathematics And Integral Calculus	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

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Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

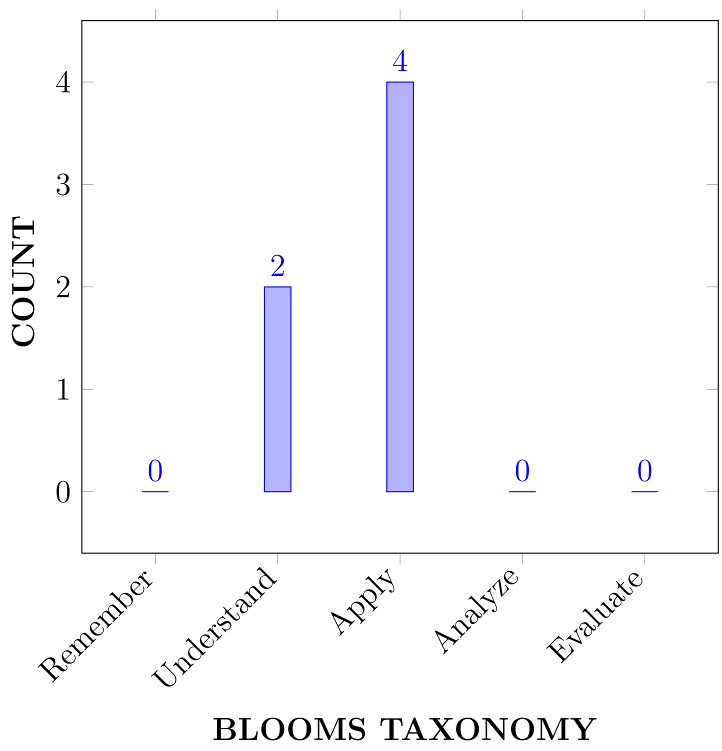
I	Enrich the knowledge of solving algebraic, transcendental and differential equation by numerical methods.
II	Apply multiple integration to evaluate mass, area and volume of the plane
III	Apply gradient, divergence and curl to evaluate the integration over a vector field
IV	Apply the Bessel's equation to solve them under special conditions with the help of series solutions.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Apply** numerical methods for solving algebric ,transcendental equations and interpolating the data	Apply
CO 2	**Make use of** least squares methods for fitting straight lines,the second degree, exponential and power curves .	Apply
CO 3	**Utilize** numerical methods for solving linear diffrential equations with initial conditions	Apply
CO 4	**Identify** the limits of definite integrals for calculating the area of solids.	Understand
CO 5	**Extend** vector operations and theorems for finding line,surface and volume integrals .	Apply
CO 6	**Determine** characterstics of special functions for solving proper and improper integrals	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.	-	Seminar/ Conferences/ Research Papers
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	-	-
PSO 3	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.	-	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	-		-	-	-	-	-	-		-	-	-
CO 5	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	-	-		-	-	-	-	-	-	-	-	-	

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Apply** the **basic properties** of numerical methods for solving algebric ,transcendental equations and interpolating the data algebra and applicability in solving (complex) majority of functions by applying **Mathematical principles**.	2
	PO 2	**Apply** the of numerical methods as a **formulation** of mathematical function in **complex engineering problems** which transformations a algibric and transcendental equations using **principle of mathematics** to attain conclusion by the **interpretation of results** .	4
CO 2	PO 1	**Make use of** the **basic properties** of least squares methods for solving fitting straight lines,the second degree, exponential and power curves by using **Mathematical principle** .	2
CO3	PO 1	**Utilize** the **basic properties** of numerical methods for solving linear diffrential equations with initial conditions by applying **Mathematical principles**.	2
	PO 2	**Apply** the of numerical methods as a **formulation** of mathematical function in **complex engineering problems** linear diffrential equations with initial conditions using **principle of mathematics** to attain conclusion by the **interpretation of results** .	4
CO4	PO 1	**Identify** the **basic properties** of the limits of definite integrals for calculating the area of solids by applying **Mathematical principles**.	2
	PO 2	**Identify** the integrals for calculating the area as a **formulation** of mathematical function in **complex engineering problems** which multiple integral using **principle of mathematics** to attain conclusion by the **interpretation of results**	4
CO5	PO1	**Extend** the vector operations and theorems for finding line,surface and volume integrals by using **priniciples of Mathematics** .	2
CO6	PO1	**Identify** the **Formulation** of improper integrals and their classification for applicability in solving special functions by applying the **principles of mathematics**.	2
	PO 2	**Solve** the of improper integrals as a **formulation** of mathematical function in **complex engineering problems** which transformatimations of equations using **principle of mathematics** to attain conclusion by the **interpretation of results** .	4

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	4	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	4	-	-		-	-	-	-	-	-		-	-	-
CO 5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	4	-	-	-	-	-	-	-	-	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	40	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.7	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.7	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.7	40	-	-		-	-	-	-	-	-		-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation
1 -5 <C$\leq$ 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	8	-	-	-	-	-	-	-	-	-	-	-	-	-
AVERAGE	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	-
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester OBE Feedback	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**ROOT FINDING TECHNIQUES AND INTERPOLATION**
	Solving algebraic and transcendental equations by bisection method, method of false position Newton-Raphson method; Interpolation: Finite differences, forward differences, backward differences and central differences; Symbolic relations; Newton's forward interpolation, Newton's backward interpolation; Gauss forward central difference formula, Gauss backward central difference formula; Interpolation of unequal intervals: Lagrange's interpolation, Newton's divided difference interpolation.
MODULE II	**CURVE FITTING AND NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS**
	Fitting a straight line; Second degree curves; Exponential curve, power curve by method of least squares. Taylor's series method; Step by step methods: Euler's, modified Euler's and Runge-Kutta method.
MODULE III	**MULTIPLE INTEGRALS**
	Double and triple integrals; Change of order of integration. Change of variables: Polar, cylindrical and spherical; Finding the area of a region using double integration and volume of a region using triple integration.
MODULE IV	**VECTOR CALCULUS**
	Scalar and vector point functions; Gradient, divergence, curl and their related properties; Solenoidal and irrotational vector point functions; Scalar potential function; Laplacian operator; Line integral, surface integral and volume integral; Vector integral theorems: Green's theorem in a plane, Stoke's theorem and Gauss divergence theorem without proofs.
MODULE V	**SPECIAL FUNCTIONS**
	Gamma function, properties of gamma function; Ordinary point and regular singular point of differential equations; Series solutions to differential equations around zero, Frobenius method about zero; Bessel's differential equation: Bessel functions properties, recurrence relations, orthogonality, generating function, trigonometric expansions involving Bessel functions.

TEXTBOOKS

1. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons Publishers, 10th Edition,2010
2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 43rd Edition,2015

REFERENCE BOOKS:

1. T.K.V Iyengar, B.Krishna Gandhi, "Engineering Mathematics - III", S. Chand & Co., 12th Edition, 2015..
2. Churchill, R.V. and Brown, J.W, "Complex Variables and Applications", Tata Mc Graw-Hill, 8th Edition, 2012.

WEB REFERENCES:

1. http://www.efunda.com/math/math_home/math.cfm
2. http://www.ocw.mit.edu/resourcs/#Mathematics
3. http://www.sosmath.com
4. http://www.mathworld.wolfram.com

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Introduction to outcome based education		
CONTENT DELIVERY (THEORY)			
2	Define Algebraic and Transcendental equations	CO 1	T1:12.1,R1:4.2
3	Apply Bisection method to find the root	CO 1	T1:12.3, R1:4.4
4	Apply False Position method to find the root	CO 1	T1:12.3, R1:4.6
5	Apply Newton-Raphson method to find roots	CO 1	T1:12.3, R1:4.7
6	Define what interpolation is	CO 1	T1:12.4, R1:4.13
7	Explain the relation between symbols	CO 1	T1:12.4, R1:4.15
8	Solve the problems by Newton's forward method	CO 1	T1:12.4, R1:4.20
9	Solve the problems by Newton's backward method	CO 1	T1:22.9 R1:5.8
10	Solve the problems by Gauss forward method	CO 1	T1:13.1, R1:5.3
11	Solve the problems by Gauss backward method	CO 1	T1:13.2, R1:5.5
12	Solve the problems by lagrange's and Newtons dividend difference	CO 1	T1:13.3, R1:5.9
13	Define Algebraic and Transcendental equations	CO 1	T1:13.4, R1:5.10

14	Apply Bisection method to find the root	CO 1	T1:14.1, R1:6.1
15	Solve the problems by lagrange's and Newtons dividend difference	CO 1	T1:14.2 , R1:6.1
16	Solve a straight line	CO 2	T1:14.4, R1:6.2
17	Solve a second degree parabola	CO 2	T1:15.2 , R1:6.6
18	Solve an exponential curve	CO 2	T1:15.1, R1:7.4,
19	Solve the ODE by Taylor's series method	CO 3	T1:15.1, R1:6.5
20	Solve the ODE by Euler's Method- Euler's modified method	CO 3	T1:15.3, R1:7.9
21	Explain the ODE by Taylor's series method	CO 3	T2: 7.14, R1:1.6
22	Explain the ODE Euler's modified method	CO 3	T2: 7.15, R1:1.63
23	Solve the ODE by Runge-Kutta Methods	CO 3	T2: 7.15, R1:1.65
24	Calculate double and triple integrations	CO 4	T2: 16.5, R1:7.32
25	Use the Change of order for multiple integrals	CO 4	T2: 16.6, R1:7.36
26	Use the Change of variables in multiple integrals	CO 4	T2: 16.7, R1:7.36
27	Apply double integration for finding the area	CO 4	T2: 16.8, R1:7.41
28	Apply triple integration for finding the volume	CO 4	T2: 16.9, R1:7.42
29	Define vector calculus and vector fields and their properties	CO 5	T2: 16.9, R1:7.42
30	Determine Gradient, divergent and curl of vector fields	CO 5	T2: 7.14, R1:1.6
31	Calculate line integral along smooth path and find work done	CO 5	T2: 7.15, R1:1.65
32	Calculate the surface area of field	CO 5	T2: 7.15, R1:1.65
33	Calculate volume of field	CO 5	T2: 7.15, R1:1.65
34	Use Green's theorem to evaluate line integrals along simple closed contours on the plane	CO 5	T2: 16.5, R1:7.32
35	Use Stokes' theorem to give a physical interpretation of the curl of a vector field	CO 5	T2: 16.6, R1:7.36
36	Use the divergence theorem to give a physical interpretation of the divergence of a vector field	CO 5	T2: 16.7, R1:7.36
37	Apply gamma function for improper integrals	CO 6	T2: 16.7, R1:7.36

38	Motivation for series solution Ordinary and regular point of a differential equation	CO 6	T2: 16.8, R1:7.41
39	Transformation of non-zero singular point to zero singular point series solutions of differential equations around zero	CO 6	T2: 16.8, R1:7.41
40	Frobenius Method about zero	CO 6	T2: 16.9, R1:7.42
41	Explain the Bessel functions	CO 6	T2: 16.5, R1:7.32
42	Determine the solution of ordinary differential equations in series form	CO 6	T1:12.3, R1:4.4
43	Apply the Frobenius method to obtain a series solution for the given linear ODE	CO 6	T1:12.3, R1:4.7
44	Demonstrate Bessel's Differential equation	CO 6	T1:12.4, R1:4.13
PROBLEM SOLVING/ CASE STUDIES			
45	Solving problems on bisection,false position method	CO 1	T1:17.1-17.2 R1:16.1-16.2
46	Solving problems on Newton Raphson method	CO 1	T1:17.5-17.6 R1:16.3.1
47	Solving problems on interpolation methods	CO 1	T1:17.1-17.2 R1:16.1-16.2
48	Solving problems on straightlines ,second degree .exponential curves least squares method	CO 2	T1:17.5-17.6 R1:16.3.1
49	Solving problems onTaylor's series method	CO 3	T1:17.1-17.2 R1:16.1-16.2
50	Solving problems onStep by step methods: Euler's, modified Euler's	CO 3	T1:23.10 R1:8.1
51	Solving problems on Runge-Kutta method	CO 3	T1:23.1 R1:9.2
52	Solving problems on Double and triple integrals	CO 4	T1:23.1 R1:9.4
53	Solving problems on Vector integral theorems	CO 5	T1:23.1 R1:9.9
54	Solving problems on properties of gamma function	CO 6	T1:23.10 R1:8.1
55	Solving problems on properties of Bessel function, Recurrence relations of Bessel function, Generating function and orthogonality of Bessel function	CO 6	T1:17.1-17.2 R1:16.1-16.2

56	Solving problems onTrigonometric expansions involving Bessel function.	CO 6	T1:17.1-17.2 R1:16.1-16.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Definitions and terminology of Module I on Root finding techniques and interpolation	CO 1	T1:23.10 R1:6.8
58	Definitions and terminology of Module II on Curve fitting and numerical solution of ordinary differential equations	CO 2, CO 3	T1:23.10 R1:7.5
59	Definitions and terminology of Module III on Multiple integrals	CO 4	T1:23.10 R1:8.1
60	Definitions and terminology of Module IV on Vector calculus	CO 6	T2:27.12 R1:11.10
61	Definitions and terminology of Module V on Special functions	CO 6	T1:17.1-17.2 R1:16.1-16.2
DISCUSSION OF QUESTION BANK			
62	Discussion of Question Bank of Module I on Root Finding Techniques and Interpolation	CO 1	T1:23.10 R1:8.1
63	Discussion of Question Bank of Module II on Curve Fitting and Numerical Solution of Ordinary Differential Equations	CO 2, CO 3	T1:23.10 R1:6.8
64	Discussion of Question Bank of Module III on Multiple Integrals	CO 4	T1:23.10 R1:7.5
65	Discussion of Question Bank of Module IV on Vector calculus	CO 5	T2:27.12 R1:11.10
66	Discussion of Question Bank of Module V on Special Functions	CO 6	T1:17.1-17.2 R1:16.1-16.2

Course Coordinator: **HOD, EEE**
Ms V Subbalaxmi , Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	COMPUTER SCIENCE AND ENGINEERING				
Course Title	ENGINEERING PHYSICS				
Course Code	AHS006				
Program	B.Tech				
Semester	I				
Course Type	Foundation				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	3	2
Course Coordinator	Mr. K. Saibaba, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Prerequisites
10+2	-	Basic Principles of Physics

II COURSE OVERVIEW:

This course develops abstract and critical reasoning by studying mathematical and logical proofs and assumptions as applied in basic physics and to make connections between physics and other branches of sciences and technology. The topics covered include nano materials, LASER, dielectric and magnetic properties, principles of quantum mechanics and semiconductors physics. The course helps students to gain knowledge of basic principles and appreciate the diverse applications in technological fields in respective branches and also in their lives.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Engineering Physics	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): he SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1.

Percentage of Cognitive Level	Blooms Taxonomy Level
0 %	Remember
60 %	Understand
40 %	Apply
0 %	Analyze

Table 1: The expected percentage of cognitive level of questions in SEE

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 2), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz/Alternative Assessment Tool.

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Table 2: Assessment pattern for CIA

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.
Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Assignment	Seminar	Term Paper
40%	40%	20%

Table 3: Assessment Pattern

VI COURSE OBJECTIVES:

The students will try to learn:

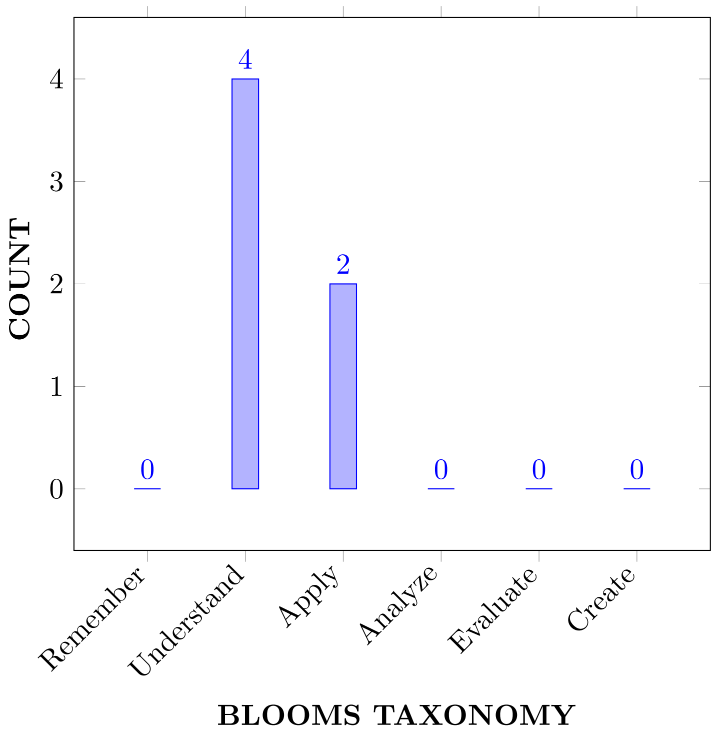
I	Develop strong fundamentals of nanomaterials.
II	Meliorate the knowledge of theoretical and technological aspects of LASER.
III	Correlate principles with applications of the quantum mechanics, dielectric and magnetic materials.
IV	Enrich knowledge in modern engineering materials like semiconductors.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Illustrate** the properties of dielectric and magnetic materials suitable for engineering applications.	Understand
CO 2	**Compare** the concepts of LASER and normal light in terms of mechanism and working principles for applications in various fields and scientific practices.	Understand
CO 3	**Illustrate** basic principle, properties and production techniques of nanomaterials.	Understand
CO 4	**Make use of** knowledge of nanomaterials to different applications in day to day life.	Apply
CO 5	**Apply** the concepts of dual nature of matter and Schrodinger wave equation to a particle enclosed in simple systems.	Apply
CO 6	**Demonstrate** the classification of solids and important aspects of semiconductors in terms of carrier concentration and Fermi level.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

Program Outcomes	
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems..	3	SEE/CIE/Quiz/ AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	SEE/CIE/Quiz/ AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	SEE/CIE/Quiz/ AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Understand, design and analyze computer programs in the areas related to Algorithms, System Software, Web design, Big data, Artificial Intelligence, Machine Learning and Networking.	-	-
PSO 2	Focus on improving software reliability, network security or information retrieval systems.	1	-
PSO3	Make use of modern computer tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	-	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH POs,PSOs:

COURSE OUTCOMES	**PROGRAM OUTCOMES**												**PSOs**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	✓	-	-	-	-	-	-	-		-	✓	-
CO 2	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	✓	-	-	-	-	-	-	-		-	-	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	✓	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	**POs PSOs**	**Justification for mapping (Students will be able to)**	**No. of Key competencies matched.**
CO 1	PO 1	**Relate** principles of different types of polarization mechanism and expression for polarizability to the properties of functional materials and for solving engineering problems by applying these principles of science.	3
	PO 2	**Explain** the given **problem statement** and **formulate** polarization versus applied electric field related to ferroelectric materials from the provided **information** and **data** by the **interpretation of hysteresis loop**.	4
	PO 1	**Utilize** spin and orbital motion of electrons in determining **magnetic moment** of materials in terms of Bohr magneton materials having specific **engineering applications**.	3
CO 1	PO 4	**Identify** the use of magnetic materials and their magnetization values for the **research based knowledge** and **technological development.**	2

Course Outcomes	POs PSOs	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 2	**Make use of** the knowledge of dielectric and magnetic materials in **Components of Electric drives**.	1
CO 2	PO 1	**Compare** the concepts of LASER and normal light in terms of mechanism, explain types of lasers and **working principle** for applications in different fields and scientific practices.	3
CO 3	PO 1	**Explain** the basic principles, properties and applications of nano materials by using **surface to volume ratio** and **quantum confinement effect.**	3
CO 4	PO 1	**Develop** the knowledge about different techniques of producing nano materials by using basic principles of nano materials	3
	PO 2	**Explain** the given **problem statement** and **formulate** procedure for fabrication of nano materials from the **information** and **data** by the **interpretation of properties of bulk materials**.	4
	PO 4	**Identify** the use of nano materials for the **research based knowledge** and **technological development.**	2
CO 5	PO 1	**Outline** drawbacks of classical mechanics, basic principles **dual nature** of matter wave, **derive** mathematical wave equation of matter waves and come to **conclusion** of quantization of energy used in quantum dots.	3
	PO 2	**Explain** the given **problem statement** and formulate quantum confinement problems related to particle enclosed in small dimension from the provided **information** and **data** in reaching substantial conclusions by the **interpretation of results**.	4
CO 6	PO 1	**Illustrate** the charge transport mechanism in intrinsic and extrinsic semiconductors using energy level diagrams, calculate their charge carrier concentration and use those expressions to integrate with other engineering disciplines .	3
	PO 4	**Identify** the use of these semiconductors under study and their conduction mechanism for the **research based knowledge** and **technological development**.	2
	PO 2	**Explain** the given **problem statement** and formulate mobility and conductivity aspects of a material from the provided **information** and **data** in reaching substantial conclusions by the **interpretation of Hall coefficient value**.	4
	PSO 2	**Make use of** the basic knowledge of semiconductors in **electrical components**.	1

Note: For Key Attributes refer **Annexure-1**

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	4	-	2	-	-	-	-	-	-	-		-	1	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	4	-	2	-	-	-	-	-	-	-		-	-	-
CO 5	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	4	-	2	-	-	-	-	-	-	-	-	-	1	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/PSO:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	40	-	18	-	-	-	-	-	-	-		-	30	-
CO 2	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	40	-	18	-	-	-	-	-	-	-		-	-	-
CO 5	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	40	-	18	-	-	-	-	-	-	-		-	30	-

XV COURSE ARTICULATION MATRIX (CO-PO/PSO MAPPING):

COs and POs and COs and PSOs on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1-5 $< C \leq 40\%$ – Low/ Slight
2 - $40\% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	1	-	-	-	-	-	-	-		-	1	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	1	-	-	-	-	-	-	-		-	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	1	-	-	-	-	-	-	-		-	1	-
TOTAL	18	8	-	3	-		-	-	-	-	-	-	-	2	-
AVERAGE	3	2	-	1	-		-	-	-	-	-	-	-	1	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

x	Assessment of mini projects by experts	✓	End Semester OBE Feedback
x	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts	-	-

XVIII SYLLABUS:

UNIT I	DIELECTRIC AND MAGNETIC PROPERTIES
	Dielectric properties: Basic definitions, electronic, ionic and orientation polarizations-qualitative; Internal field in solids; Magnetic properties: Basic definitions, origin of magnetic moment, Bohr magneton, classification of dia, para and ferro magnetic materials on the basis of magnetic moment, domain theory of ferro magnetism on the basis of hysteresis curve.
UNIT II	LASERS
	Lasers: Characteristics of lasers, spontaneous and stimulated emission of radiation, metastable state, population inversion, lasing action, Einstein's coefficients, ruby laser, He-Ne laser, semiconductor diode laser and applications of lasers.
UNIT III	NANOMATERIAL
	Nanomaterial: Origin of nanomaterial, nano scale, surface to volume ratio, quantum confinement; Properties of nanomaterials: Physical, chemical, electrical, optical, magnetic and mechanical. Bottom-up fabrication: Sol-gel; Top-down fabrication: Chemical vapour deposition; Applications of nanomaterials, characterization by XRD, TEM.
UNIT IV	QUANTUM MECHANICS
	Introduction to quantum physics, Black body radiation, Planck's law, Photoelectric effect, Compton effect, De-Broglie's hypothesis, Wave-particle duality, Davisson and Germer experiment, Time-independent Schrödinger equation for wave function, Born interpretation of the wave function, Schrödinger equation for one dimensional problems–particle in a box.
UNIT V	SEMICONDUCTOR PHYSICS
	Semiconductor physics: Fermi level in intrinsic and extrinsic semiconductors, calculation of carrier concentration in intrinsic and extrinsic semiconductors, energy gap, direct and indirect band gap semiconductors, Hall effect.

TEXTBOOKS

1. Dr. K Vijay Kumar and Dr. S Chandralingam — Modern Engineering Physics‖ Chand & Co.NewDelhi,1st Edition, 2010.
2. P. K. Palanisamy —Engineering Physics‖,Scitech Publishers, 4th Edition, 2014.

REFERENCE BOOKS:

1. V. Rajendran—Engineering Physics‖, Tata McGraw Hill Book Publishers, 1st Edition, 2010.
2. R. K. Gaur, S. L. Gupta, -Engineering Physics‖, DhanpatRai Publications, 8th Edition,2001.
3. A. J. Dekker-Solid State Physics‖Macmillan India ltd, 1st Edition, 2000.
4. Hitendra K. Malik, A. K. Singh-Engineering Physics‖McGraw Hill Education, 1st Edition, 2009.

WEB REFERENCES

1. http://link.springer.com/book
2. http://www.thpys.physics.ox.ac.uk
3. http://sciencedirect.com/science
4. http://www.e-booksdirectory.com

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be some changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT THEORY(DELIVERY)			
2	Acquire knowledge of basic terms related to dielectric materials.	CO 1	T1:13.5 R1:1.3
3	Discuss different polarization mechanisms in dielectrics	CO 1	T1:13.5 R1:1.3
4	Derive expression for total electric field at a given point inside dielectrics.	CO 1	T1:13.5 R1:1.3
5	Acquire knowledge of basic terms related to magnetic materials.	CO 1	T1:14.7 R1:3.4
6	Describe magnetic moment in an atom in terms of Bohr Magneton	CO 1	T1:15.7 R1:4.10
7	Classify different magnetic materials based on electron theory.	CO 1	T1:16.8 R1:4.15
8	Examine the spontaneous magnetization in ferro-magnets based on orientation of domains.	CO 1	T1:16.9 R1:5.4
9	Explain the principle involved in Lasers	CO 2	T1:17.9 R1:5.8
10	Review basic phenomena's of laser	CO 2	T1:18.10 R1:6.8
11	Discuss functioning of laser system	CO 2	T1:19.9 R1:7.5
12	Derive relation between Einstein's Coefficients	CO 2	T1:23.10 R1:7.5
13	Explain the principle and working of Ruby laser	CO 2	T1:23.10 R1:8.1
14	Explain the principle and working of Helium-Neon laser	CO 2	T1:23.1 R1:9.2
15	Explain the principle and working of semiconductor diode laser	CO 2	T1:23.1 R1:9.4
16	Explain the principle and working of Helium-Neon laser	CO 2	T1:23.1 R1:9.9
17	Explain the principle and working of semiconductor diode laser	CO 2	T1:23.1 R1:9.10
18	Discuss the uses of lasers	CO 2	T2:27.5 R1:10.2
19	Identify the principle of nano technology	CO 3	T2:27.7 R1:11.3

20	Recall origin of nanomaterials	CO 5	T2:27.8 R1:11.6
21	Acquire knowledge of basic principle of nanomaterials.	CO 3	T2:27.12 R1:11.7
22	Analyze nano material with their properties	CO 3	T2:27.12 R1:11.8
23	Develop nanomaterials in sol gel method	CO 4	T2:27.12 R1:11.9
24	Develop nanomaterials chemical method	CO 4	T2:27.12 R1:11.10
25	Discuss applications of nanomaterials	CO 4	T2:27.14 R1:12.3
26	Analyze nanomaterials by XRD	CO 4	T2:27.1 R1:12.7
27	Analyze nanomaterials by TEM	CO 4	T2:27.17 R1:12.15
28	Understand dual nature of radiation	CO 5	T2:27.18 R1:12.19
29	Correlate dual nature to material particle	CO 5	T2:27.19 R2:14.4
30	Analyze matter wave concept mathematically	CO 5	T2:27.20 R2:14.5
31	Describe matter waves and Heisenberg's Uncertainty Principle	CO 5	T2:30.19 R2:14.5
32	Identify existence of matter wave experimentally	CO 5	T2:30.20 R2:15.5
33	Derive wave equation of matter wave	CO 5	T2:32.19 R2:16.5
34	Correlate wave function to probability density.	CO 5	T2:32.20 R2:16.5
35	Derive the solution of wave equation in terms of Potential box	CO 5	T2:33.1 R2:16.6
36	Apply to three dimensions	CO 5	T2:34.1 R2:17.1
37	Explain basic concepts of semiconductors	CO 6	T2:35.2 R2:17.2
38	Derive carrier concentration in intrinsic Semiconductors	CO 6	T2:36.1 R2:18.1
39	Identify Fermi level in semiconductors	CO 6	T2:39.19 R2:16.5
40	Determine energy gap mathematically	CO 6	T2:40.19 R2:16.5
41	Compare Direct &Indirect Band Gap semiconductors, Hall Effect	CO 6	T2:41.19 R2:16.5

PROBLEM SOLVING			
1	Dielectric constant, capacitance, permittivity	CO 1	T2:16.5; R3:8.10
2	Electric susceptibility, Polarization vector	CO 1	T2:16.5; R3:8.10
3	Polarizability	CO 1	T1:3.3.1; R3:3.2
4	Magnetic moment, Magnetic induction, Permeability	CO 1	T2:16.5; R3:8.10
5	Intensity of magnetization, Magnetic susceptibility	CO 1	T2:16.5; R3:8.10
6	Wavelength and Energy bandgap	CO 2	T2:16.5; R3:8.10
7	Divergence	CO 2	T2:16.5; R3:8.10
8	Relative population of two states	CO 2	T1:3.3.1; R3:3.2
9	Number of photons emitted	CO 2	T1:3.3.1; R3:3.2
10	De-broglie wavelength	CO 5	T1:3.3.1; R3:3.2
11	Energies associated with one dimensional potential box	CO 5	T2:16.5; R3:8.10
12	Intrinsic carrier concentration, Fermi level in semiconductors	CO 6	T2:16.5; R3:8.10
13	Carrier concentration based on Hall coefficient	CO 6	T1:3.3.1; R3:3.2
14	Mobility and conductivity based on Hall coefficient	CO 6	T2:16.5; R3:8.10
15	Diffusion and drift	CO 6	T2:16.5; R3:8.10
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Dielectric And Magnetic Properties	CO 1	T2:16.5; R3:8.10
2	LASER	CO 2	T1:3.3.1; R3:3.2
3	Nanomaterial	CO 3, CO 4	T2:16.5; R3:8.10
4	Quantum Mechanics	CO 5	T2:16.5; R3:8.10
5	Semiconductor Physics	CO 6	T2:16.5; R3:8.10
DISCUSSION OF QUESTION BANK			
1	Dielectric And Magnetic Properties	CO 1	T2:16.5; R3:8.10

2	LASER	CO 2	T1:3.3.1; R3:3.2
3	Nanomaterial	CO 3, CO 4	T2:16.5; R3:8.10
4	Quantum Mechanics	CO 5	T2:16.5; R3:8.10
5	Semiconductor Physics	CO 6	T2:16.5; R3:8.10

Signature of Course Coordinator **HOD**

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions	**10**

	5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**

PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project.	**12**

	6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	
PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**
PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer. 1. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**					
Course Title	**ENGINEERING CHEMISTRY**					
Course Code	AHS005					
Program	B.Tech					
Semester	I					
Course Type	FOUNDATION					
Regulation	IARE - R16					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	3	1	3	3	3	
Course Coordinator	Dr V Anitha Rani, Associate Professor					

I COURSE OVERVIEW:

The primary objective of an Engineering Chemistry course is to introduce the students to the concepts and applications of chemistry in engineering. It should cultivate in them an ability to identify chemistry in each piece of finely engineered products used in households and industry. It aims to strengthen the fundamental concepts of chemistry and then builds an interface with their industrial applications. It deals with applied and industrially useful topics, such as water technology, engineering materials, electrode potential and cells, fuels, polymers and corrosion. This course will involve minimum lecturing, content will be delivered through assigned reading and reinforced with large and small group discussions, as well as assigned in class (and occasional out of class) group activities. Water and its treatment for various purposes, engineering materials such as plastics, composites, ceramic, abrasives, their preparation, properties and applications, conventional and non-conventional energy sources, nuclear, solar, various batteries, combustion calculations, corrosion and control of metallic materials.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
10+2	-	-	Basic Principles of chemistry

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Engineering chemistry	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOCs
x	Open Ended Experiments	✓	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table below.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
50%	Understand
50%	Apply
0%	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 2), with 25 marks for Continuous Internal Examination and (CIE), 05 marks for Quiz.

Component	Theory		
Type of Assessment	CIE Exam	Quiz	Total Marks
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz –Online Examination:
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

VI COURSE OBJECTIVES:

The students will try to learn:

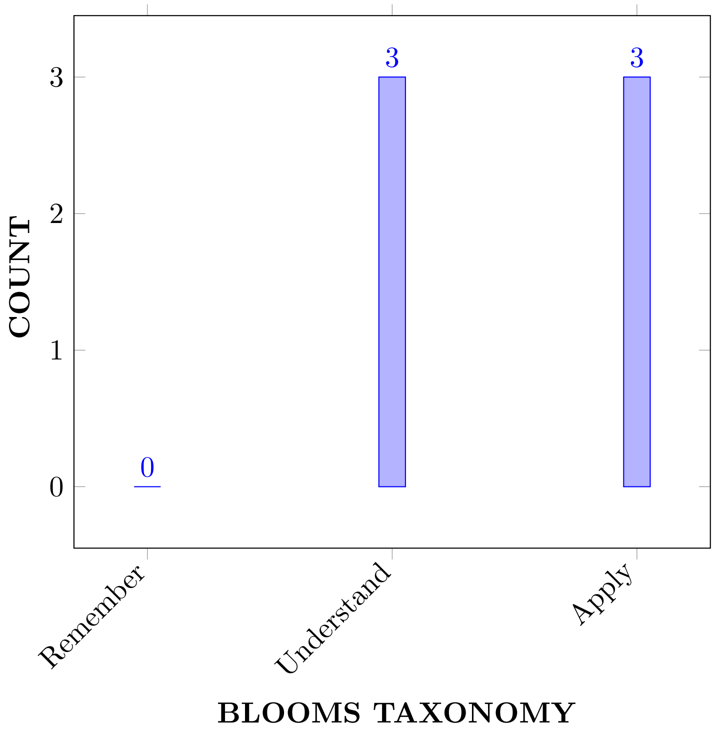
I	The concepts of electrochemical principles and causes of corrosion in the new development and breakthroughs efficiently in engineering and technology.
II	The different parameters to remove causes of hardness of water and their reactions towards the complexometric method.
III	The polymerization reactions with respect to mechanisms and its significance in industrial applications.
IV	The properties, separation techniques of natural gas and crude oil along with potential applications in major chemical reactions.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the operation of electrochemical systems for the production of electric energy, i.e. batteries.	Understand
CO 2	**Utilize** electrochemical cell parameters, electrochemical active surface area, current and over potential under given condition for calculating the electromotive force and electrode potential.	Apply
CO 3	**Illustrate** the electrochemical theory of corrosion process in metals for protection of different metals from corrosion.	Understand
CO 4	**identify** the Hardness of water by different treatment methods for finding the hardness causing salts in water	Apply
CO 5	**Explain** the importance of different types of materials for understanding their composition and applications.	Understand
CO 6	**Choose** different types of solid, liquid and gaseous fuels in terms of calorific value for utilizing in industries and automobiles.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/CIE /Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	SEE/CIE /Quiz/AAT
PO 7	**Environment and sustainability:** understand the impact of the professional engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development. .	3	SEE/CIE /Quiz/AAT

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.	-	-
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	-	-
PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer.	-	-

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓		-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	-	-	-	-	✓	-	-	-	-	-	-	-	-

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

Course Outcomes (COs)	POs / PSOs	Justification for mapping (Students will be able to)	No. of key competencies
CO 1	PO 1	**Apply** the electrochemical properties for producing electrical energy (understand) by using **principles of science** for solving **engineering problems.**	2
CO 2	PO 1	**Choose** different electrodes for finding pH of unknown solutions by applying **mathematical** expressions of cell potential by using **principles of science** and mathematics for solving **engineering** problems	3
	PO 2	**Identify** the problem **formulation and abstraction** for calculating electrode potential under non standard conditions by applying Nernst equation from the provided **information.**	2
CO 3	PO 1	**Explain**the corrosion processes in metals by exposing to acidic and alkaline environment, corrosion control methods like metallic coatings, cathodic protection to prevent corrosion in different metals by using principles of science **engineering** problems by applying the **principles of science**	2
CO 4	PO 1	**Explain** the Hardness of water by different treatment methods for finding the hardness causing salts in water **mathematical expressions** for solving **engineering** problems.	3
	PO 2	**Identify** the problem and formulate for finding the hardness of water in terms of CaCO3 equivalents with given **information and data** by applying principles of science.	2
CO 5	PO 1	**Relate** the importance of different types of materials such as polymers, lubricants, cement and refractories for understanding their composition and applications by using **mathematical** expressions for finding the **principles of science and mathematics** for solving **engineering** problems.	2
CO 6	PO 1	**Choose** different types of solid, liquid and gaseous fuels with their characteristics and calorific value by applying mathematical expressions for finding calorific value using principles of science for solving **engineering** problems by applying the **principles of science.**	2

	PO 2	**Identify** the problem and formulate for finding the hardness of water in terms of CaCO3 equivalents with given **information and data** by applying principles of science.	2
	PO 7	**Make** use of gaseous fuels like LPG, CNG to reduce the pollutants in atmosphere and know the impact in socio economic and environmental contexts for sustainable development.	2

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	Program Outcomes/ No. of Key Competencies Matched												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	-	-	2	-	-	-	-	-	-	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.6	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.6	20	-	-	-	-	66.6	-	-	-	-	-	-	-	-

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - $0 \leq$ C$\leq$ 5% – No correlation
1-5 <C$\leq$ 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	1	-	-	-		3	-	-	-	-	-	-	-	-
TOTAL	18	3	-	-	-	-	3	-	-	-	-	-	-	-	-
AVERAGE	3	1	-	-	-	-	3	-	-	-	-	-	-	-	-

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO1,PO2,PO7	SEE Exams	PO1,PO2,PO7	Seminars	PO1,PO2,PO7
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	PO1,PO2,PO7	5 Minutes Video	PO1,PO2,PO7	Open Ended Experiments	PO1,PO2,PO7
Assignments	PO1,PO2,PO7				

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVII SYLLABUS:

MODULE I	**ELECTROCHEMISTRY AND BATTERIES**
	Electrochemistry: Basic concepts of electrochemistry; Conductance: Specific, equivalent and molar conductance and effect of dilution on conductance; Electrochemical cells: Galvanic cell (daniel cell); Electrode potential; Electrochemical series and its applications; Nernst equation; Types of electrodes: Calomel electrode, quinhydrone electrode; Batteries: Classification of batteries, primary cells (dry cells) and secondary cells (lead-acid battery, Ni-Cd cell), applications of batteries, numerical problems.
MODULE II	**CORROSION AND ITS CONTROL**
	Corrosion: Introduction, causes and effects of corrosion; Theories of corrosion: Chemical and electrochemical corrosion with mechanism; Factors affecting the rate of corrosion: Nature of the metal and nature of the environment; Types of corrosion: Waterline and crevice corrosion; Corrosion control methods: Cathodic protection- sacrificial anodic protection and impressed current cathodic protection; Surface coatings: Metallic coatings, methods of application of metallic coatings-hot dipping(galvanizing, tinning), electroplating(copper plating); Organic coatings: Paints, its constituents and their functions
MODULE III	**WATER TECHNOLOGY**

	Water: Sources and impurities of water, hardness of water, expression of hardness-units; Types of hardness: Temporary hardness, permanent hardness and numerical problems; Estimation of temporary and permanent hardness of water by EDTA method; Determination of dissolved oxygen by Winkler's method; Boiler troubles: Priming, foaming, scales, sludges and caustic embrittlement. Treatment of water: Internal treatment of boiler feed water- carbonate, calgon and phosphate conditioning, softening of water by Zeolite process and Ion exchange process; Potable water-its specifications, steps involved in the treatment of potable water, sterilization of potable water by chlorination and ozonization, purification of water by reverse osmosis process.
MODULE IV	**MATERIALS CHEMISTRY**
	Materials chemistry: Polymers-classification with examples, polymerization-addition, condensation and co-polymerization; Plastics: Thermoplastics and thermosetting plastics; Compounding of plastics; Preparation, properties and applications of polyvinyl chloride, Teflon, Bakelite and Nylon-6, 6; Rubbers: Natural rubber its process and vulcanization; Elastomers: Buna-s and Thiokol rubber; Fibers: Characteristics of fibers, preparation properties and applications of Dacron; Characteristics of fiber reinforced plastics; Cement: Composition of Portland cement, setting and hardening of Portland cement; Lubricants: Classification with examples; Properties: Viscosity, flash, fire, cloud and pour point; Refractories: Characteristics and classification with examples..
MODULE V	**FUELS AND COMBUSTION**
	Fuel: Definition, classification of fuels and characteristics of a good fuels; Solid fuels: Coal; Analysis of coal: Proximate and ultimate analysis; Liquid fuels: Petroleum and its refining; Cracking: Fixed bed catalytic cracking; Knocking: Octane and cetane numbers; Gaseous fuels: Composition, characteristics and applications of natural gas, LPG and CNG; Combustion: Calorific value: Gross Calorific Value(GCV) and Net Calorific Value(NCV), calculation of air quantity required for complete combustion of fuel, numerical problems.

TEXTBOOKS

1. P. C. Jain and Monica Jain, "Engineering Chemistry", Dhanpat Rai Publishing Company, 16th Edition, 2017.
2. Shashi Chawla, "Engineering Chemistry", Dhanat Rai and Company, 2011, 1st Edition.
3. Prashanth rath, B.Rama Devi, Ch.Venkata Ramana Reddy, Subhendu Chakroborty, Cengage Learning Publishers, 1st Edition, 2018
4. Anubha Kaushik, C.P.Kaushik, "Environmental Studies" New Age International publishers, 4th Edition, 2015.
5. Dr B.N.Srinivas, P.Kishore, K.Subba Rao "Engineering Chemistry" University Science Press,2015,1st Edition.

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1. Dr.Bharathi Kumari, "A text book of Engineering Chemistry", VGS Book Links, 8th Edition,2016.
2. B. Siva Shankar, "Engineering Chemistry", Tata McGraw Hill Publishing Limited, 3rd Edition, 2015.

3. S. S. Dara, Mukkanti, “Text of Engineering Chemistry”, S. Chand & Co, New Delhi, 12thEdition, 2006.

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	Course outcomes	Text (T) book / Reference (R) book
1	Understands the concept of electrochemistry. Differentiate the electronic conductors and electrolytes	CO 1	T1:6.1 R1: 2.6
2	Define the terms specific, equivalence and molar conductance. Explain the dilution effect on these conductance	CO 1	T1:6.1 R1: 2.6
3	Understands the concept of specific, equivalence and molar conductance. Define the EMF of the cell.Demonstrate the Daniel cell.	CO 1	T1:6.2 R1: 2.9
4	Describe the construction and chemical reactions of different electrodes.the Calomel electrode	CO 1	T1:6.5 R1: 2.6.3
5	Quinhydrone electrodes in calculation of potential of the single electrode.	CO 1	T1: 6.7 R1:2.12
6	Derive the relation between cell reaction and emf of the single electrodes.	CO 1	T1:6.12 R1: 2.12
7	Use the standard potential values of elements from electrochemical series	CO 2	T1:7.1 R1:2.14
8	Corrosion: Introduction, causes and effects of corrosion	CO 2	T1:7.2 R1:2.17
9	Theories of corrosion: Chemical and electrochemical corrosion with mechanism.	CO 2	T1:7.14 R1:2.20
10	Factors affecting the rate of corrosion: Nature of the metal and nature of the environment	CO 2	T1:7.14 R1: 2.22
11	Define the battery; differentiate the primary and secondary batteries. Demonstrate the construction of the dry cell	CO 3	T1:1.3 R1: 1.4
12	Identify the anode, cathode and electrolyte in different types of secondary batteries	CO 2	T1:1.3,1.5 R1:1.6.1,1.6.3
13	Employ the applications of different types of batteries.	CO 2	T1:1.5 R1: 1.6.2

14	Define corrosion and its disadvantages	CO 2	T1:1.14 R1: 1.6.4
15	Explain the mechanism of oxidation corrosion when dry gases attack on metal..	CO 2	T1:1.12 R1: 1.6.5
16	Explain the mechanism of hydrogen evolution type and oxygen absorption type corrosion.	CO 2	T1:1.11 R1:1.8.1
17	Distinguish the types of corrosion.	CO 2	T1:1.13 R1:1.10
18	Analyze the effect of different factors on rate of corrosion.	CO 2	T1:1.4 R1: 3.1.4
19	Explain the process of cathodic protection with examples.	CO 2	T1:1.4 R1: 3.1.4
20	Use the methods of application of metallic coatings and Relate the galvanization and tinning	CO 2	T1: 3.12 R1: 3.2.2
21	Explain the process of electroplating. Apply the organic coatings for control of corrosion	CO 2	T1: 3.12 R1: 3.2.2
22	List the various sources of water, Differentiate the temporary and permanent hardness and give its units.	CO 3	T1:3.14 R1: 3.2.3
23	Calculate the total, permanent and temporary hardness of sample hard water by using EDTA	CO 3	T1: 3.15 R1:3.2.3
24	Calculate the dissolved oxygen in water by Winkler's method	CO 3	T1: 3.22 R1:3,3.4
25	Recognize the boiler troubles.	CO 3	T1: 3.24 R1: 3.5
26	Discuss the internal treatment methods of boiler feed water. Name the different chemicals used in internal treatment	CO 3	T1: 3.25 R1: 3.7
27	Explain the process of zeolite and analyze the advantages and disadvantages.	CO 3	T5:6.8 T2:1.1
28	Explain ion-exchange process. Demonstrate the treatment of potable water.	CO 3	T5: 6.8.3 T2: 8.1
29	Purification of potable water. Describe the process of reverse osmosis	CO 3	T5: 6.8.3 T2:9.2
30	Define monomer and polymer Explain the mechanism of different types of Chain and step growth polymerization	CO 4	T1:4.2 R1:6.2.1
31	Distinguish the thermoplastic and thermo set plasitcs. Illustrate the compounding of plastics.	CO 4	T1:4.4.1 R1:7.1

32	Identify the preparation, properties and applications of different thermo and thermo set plastics	CO 4	T1:4.5.2 R1:15.2
33	Identify the preparation, properties and applications of thermo set plastics. Explain about natural rubber	CO 4	T1:4.6 R1:9.2
34	Explain the preparation, properties and applications of synthetic rubbers.	CO 4	T1:4.8 R1:5.2
35	Explain the preparation, properties and applications of fibers. Generalize the process of setting and hardening reactions of cement	CO 4	T4:2.1
36	Define the term lubricant and it's classification.	CO 5	T4:2.2
37	Compare the different types of lubricants based on their properties	CO 5	T4:2.3
38	Name the different types of refractories. Discuss the characteristics and applications of refractories	CO 5	T4:2.5,5.2
39	Define the fuel with examples. Categorize the different types of fuels	CO 6	T4: 4.2
40	Analyze the different types of coals. Explain the significance of proximate analysis of coal. Explain the significance of Ultimate analysis of coal	CO 6	T4: 4.6
41	Identify the chemical constituents of petroleum. Describe the refining of petroleum. Define the term cracking. Distinguish the fixed bed and catalytic cracking	CO 6	T4:4.12
42	Evaluate the octane and cetane rating of the petrol and diesel	CO 6	T1:6.2 R1: 2.9
43	Identify the chemical constituents of the gaseous fuel. Discuss the characteristics of natural gas. Compare the LPG and CNG	CO 6	T1:6.5 R1: 2.6.3
44	Explain the combustion process of different chemical constituents present in the fuel. Differentiate the HCV and LCV.	CO 6	T1:6.2 R1: 2.9
45	Evaluate the air quantity required for complete combustion of fuel	CO 6	T1:6.5 R1: 2.6.3

Course Coordinator: **HOD, EEE**
Dr V Anitha Rani, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043
COMPUTER SCIENCE AND ENGINEERING
COURSE DESCRIPTION

Course Title	**COMPUTER PROGRAMMING**				
Course Code	ACS001				
Program	B.Tech				
Semester	I	AE|ME			
	II	CSE|IT|ECE |EEE			
Course Type	Foundationl				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	4	2
Course Coordinator	Mr.P Ravinder , Assistant Professor				
Course Faculty	Dr J Sirisha Devi, Associate Professor, CSE Dept				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	ACSS001	I	Basic Programming Concepts	-

II COURSE OVERVIEW:

The course emphasis on the problem-solving aspects in using C programming. It is the fundamental course and is interdisciplinary in nature for all engineering applications. The students will understand programming language, programming, concepts of loops, reading a set of data, step wise refinements, functions, control structures, arrays, dynamic memory allocations, enumerated data types, structures, unions, and file handling. This course provides adequate knowledge to solve problems in their respective domains.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
PPSC	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	✓	MOOC
x	Open Ended Experiments	✓	Seminars	✓	Mini Project	✓	Videos
✓	Others: Quiz						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1.

Percentage of Cognitive Level	Blooms Taxonomy Level
16.66%	Remember
25 %	Understand
58.33 %	Apply
0 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz / Alternative Assessment Tool (AAT):

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are be answered by choosing the correct answer from a given set of choices (commonly four). Marks shall be awarded considering the average of two quizzes for every course. The AAT may include seminars, assignments, term paper, open ended experiments, five minutes video and MOOCs.

VI COURSE OBJECTIVES:

The students will try to learn:

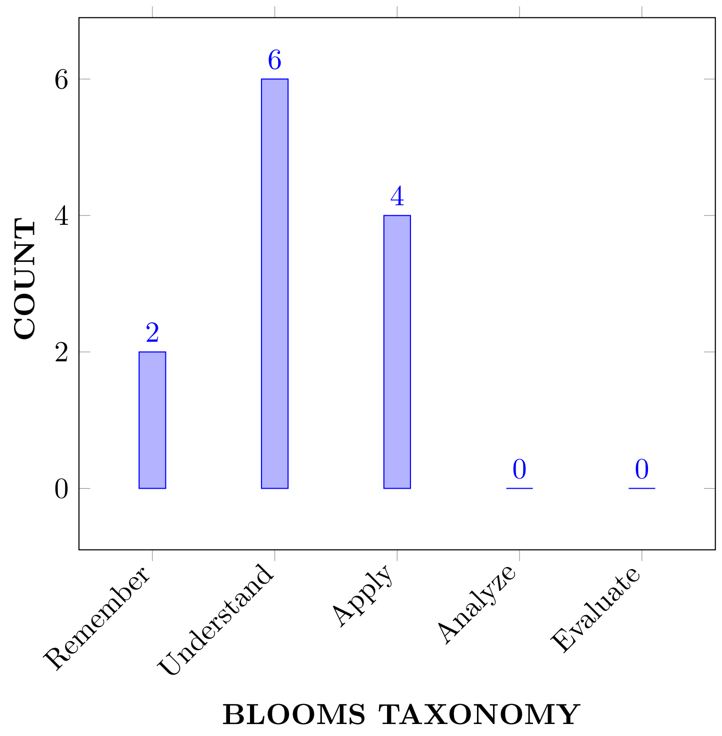
I	Learn adequate knowledge by problem solving techniques.
II	Understand programming skills using the fundamentals and basics of C Language.
III	Improve problem solving skills using arrays, strings, and functions
IV	Understand the dynamics of memory by pointers.
V	Study files creation process with access permissions.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Illustrate** problem solving steps in terms of algorithms, pseudocode, flowcharts and programs with basic data types and operations for Mathematical and Engineering problems.	Understand
CO 2	**Implement** derived data types, operators in C program statements.	Apply
CO 3	**Construct** programs involving decision structures, loops, arrays and strings.	Apply
CO 4	**Make use of** various types of functions, parameters, and return values for complex problem solving.	Apply
CO 5	**Illustrate** the static and dynamic memory management with the help of structures, unios and pointers.	Understand
CO 6	**Extend** file input and output operations in implementation of real time applications.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES ARE ASSESSED:

Program	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** : Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** : Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Assignments

PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	Assignments
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	Seminars, Viva
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1	5 minutes video

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	**Professional Skills:** The ability to understand, analyze and develop computer programs in the areas related to algorithms, system software, multimedia, web design, big data analytics, and networking for efficient design of computer-based systems of varying complexity.	2	Projects
PSO 2	**Problem-Solving Skills:** The ability to apply standard practices and strategies in software project development using open-ended programming environments to deliver a quality product for business success.	3	Lectures, Assignments
PSO 3	**Successful Career and Entrepreneurship:** The ability to apply standard practices and strategies in software project development using open-ended programming environments to deliver a quality product for business success.	3	Lectures, Assignments

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE	**PROGRAM OUTCOMES**												**PSO'S**		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	-	-	-	✓	-	-	-	-	✓	-	✓	-	-	-
CO 2	✓	✓	✓	-	✓	-	-	-	-	✓	-	✓	✓	-	-
CO 3	✓	✓	-	-	✓	-	-	-	-	✓	-	✓	✓	-	✓

CO 4	✓	✓	✓	-	✓	-	-	-	-	✓	-	✓	-	-	✓
CO 5	✓	-	-	-	✓	-	-	-	-	✓	-	✓	-	-	-
CO 6	✓	-	-	-	✓	-	-	-	-	✓	-	✓	✓	-	-

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Understand the basics of computers; **Fundamentals** of Computer System and memory organization, and **identify** the components of the computer system.	3
CO 2	PO 1	Developing algorithms and draw flowcharts for solving **mathematical** and **engineering problems** related to **areas of computer science.**	3
	PO 2	Understand the various symbols to **draw**a flowchart, **identify** the appropriate symbols to solve a problem, then **formulate** the solution, and **interpret** the result for the **improvement** of the solution.	5
	PO3	**Recognize** an appropriate control structure to **design** and **develop** a solution for a **real-time** scenario, and communicating effectively with engineering community.	3
	PO5	Describe the operators, their precedence, and associativity while evaluating expressions in **software program**.	1
	PSO1	Understand the features of procedural programming for **designing** and **analysing** computer programs for **problem-solving**.	3
CO 3	PO 1	Apply the knowledge of **mathematics, C language fundamentals** to design, develop, and debug programs to solve **engineering** problems	3
	PO 2	Understand the **problem statement**, identify the **data requirements, design**, and **develop** a system for an engineering problem, **validate** and **interpret** the results.	5
	PSO 1	**Understand** automatic type conversion rules to **determine** the magnitude and precision of a mixed datatype expression in the areas of **software development.**	4
CO 4	PO 1	Describe the **fundamental programming** constructs, and articulate how they are used to **develop a program** with a desired runtime execution flow.	3
	PO 2	**Identify** the appropriate datatypes to **formulate, develop** and **analyze** the solution to achieve **engineering** objectives.	5

	PO 3	Recognize right **data representation** formats based on the **requirements** for **developing programs** in **real-time scenarios** by **managing** the **design process**, and communicating effectively with **engineering** community.	7
	PO 5	Describe the operators, their precedence, and associativity while evaluating expressions in **software program.**	1
CO 5	PO 1	Understand branching statements, loop statements, and apply the fundamentals of **mathematics, science** and **engineering.**	3
	PO 2	Understand the **problem statement, control** the flow of data, **design** the solution and **analyse** the same to **validate** the results in a program to solve complex engineering problems.	5
	PO 3	**Recognize** an appropriate control structure to **design** and **develop** a solution for a **real-time** scenario, and **communicating** effectively with engineering community.	6
CO 6	PO 1	Make use of **engineering techniques** to design and develop solutions for real-time **computational problems.**	3
	PSO 1	**Identify** tasks in which the numerical techniques are **applicable, develop** programs, and hence use computers effectively to solve**real-time applications.**	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	Program Outcomes/ No. of Key Competencies Matched												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	1	-	-	-	-	2	-	4	-	-	-
CO 2	3	5	3	-	1	-	-	-	-	2	-	3	3	-	-
CO 3	3	5	-	-	1	-	-	-	-	2	-	3	4	1	1
CO 4	3	5	7	-	1	-	-	-	-	2	-	3	-	1	1
CO 5	3	5	6	-	1	-	-	-	-	2	-	3	-	-	-
CO 6	3	-	-	-	1	-	-	-	-	2	-	3	2	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	-	-	-	100	-	-	-	-	40	-	50	-	-	-

CO 2	100	50	30	-	100	-	-	-	-	40	-	50	50	-	-
CO 3	100	50	-	-	100	-	-	-	-	40	-	50	67	50	50
CO 4	100	50	70	-	100	-	-	-	-	40	-	50	-	50	50
CO 5	100	50	60	-	100	-	-	-	-	40	-	50	-	-	-
CO 6	100	-	-	-	100	-	-	-	-	40	-	50	34	-	-

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - $0 \leq C \leq 5\%$ – No correlation
2 - 40 % $<C < 60\%$ –Moderate
1-5 $<C \leq 40\%$ – Low/ Slight
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	**PROGRAM OUTCOMES**												**PSO'S**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	3	-	-	-	-	2	-	2	-	-	-
CO 2	3	2	1	-	3	-	-	-	-	2	-	2	2	-	-
CO 3	3	2	-	-	3	-	-	-	-	2	-	2	3	-	2
CO 4	3	2	3	-	3	-	-	-	-	2	-	2	-	-	2
CO 5	3	2	3	-	3	-	-	-	-	2	-	2	-	-	-
CO 6	3	-	-	-	3	-	-	-	-	2	-	2	1	-	-
TOTAL	18	8	7	-	18	-	-	-	-	10	-	10	6	-	4
AVERAGE	3	2	2	-	3	-	-	-	-	1.67	-	1.67	2	-	2

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1,PO 2, PO 3, PO 4	SEE Exams	PO 1, PO 2, PO 3, PO 4	Seminars	PO 3
Laboratory Practices	PO 1	Student Viva	PO3	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments	PO 2	-	-	-	-

XVII ASSESSMENT METHODOLOGY INDIRECT:

X	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVIII SYLLABUS:

MODULE I	**INTRODUCTION**
	Introduction to computers: Computer systems, computing environments, computer languages, creating and running programs, algorithms, flowcharts; Introduction to C language: History of C, basic structure of C programs, process of compiling and running a C program, C tokens, keywords, identifiers, constants, strings, special symbols, variables, data types; Operators and expressions: Operators, arithmetic, relational and logical, assignment operators, increment and decrement operators, bitwise and conditional operators, special operators, operator precedence and associativity, evaluation of expressions, type conversions in expressions, formatted input and output.
MODULE II	**CONTROL STRUCTRES**
	Control structures: Decision statements; if and switch statement; Loop control statements: while, for and do while loops, jump statements, break, continue, goto statements; Arrays: Concepts, one dimensional arrays, declaration and initialization of one dimensional arrays, two dimensional arrays, initialization and accessing, multi dimensional arrays; Strings concepts: String handling functions, array of strings.
MODULE III	**ARRAYS AND FUNCTIONS**
	Functions: Need for user defined functions, function declaration, function prototype, category of functions, inter function communication, function calls, parameter passing mechanisms, recursion, passing arrays to functions, passing strings to functions, storage classes, preprocessor directives. Pointers: Pointer basics, pointer arithmetic, pointers to pointers, generic pointers, array of pointers, pointers and arrays, pointers as functions arguments, functions returning pointers.
MODULE IV	**POINTERS AND STRUCTURES**
	Structures and unions: Structure definition, initialization, accessing structures, nested structures, arrays of structures, structures and functions, passing structures through pointers, self referential structures, unions, bit fields, typedef, enumerations; Dynamic memory allocation: Basic concepts, library functions.
MODULE V	**FILE HANDLING AND APPLICATIONS IN C**
	Files: Streams, basic file operations, file types, file opening modes, file input and output functions, file status functions, file positioning functions, command line arguments.

TEXT BOOKS

1. Byron Gottfried, —Programming with C, Schaum's Outlines Series, McGraw Hill Education, 3rd Edition, 2017.

2. Reema Thareja —Programming in C, Oxford university press, 2nd Edition, 2016.

REFERENCE BOOKS:

1. W. Kernighan Brian, Dennis M. Ritchie —The C Programming Language, PHI Learning, Second Edition, 1988.

2. YashavantKanetkar —Exploring C, BPB Publishers, Second Edition, 2003..
3. Schildt Herbert —C: The Complete Reference, Tata McGraw Hill Education, Fourth Edition, 2014.

Web References:

1. https://www.bfoit.org/itp/Programming.html
2. https://www.khanacademy.org/computing/computer-programming
3. https://www.edx.org/course/programming-basics-iitbombayx-cs101-1x-0
4. https://www.edx.org/course/introduction-computer-science-harvardx-cs50x

E-Text Books:

1. http://www.freebookcentre.net/Language/Free-C-Programming-Books-Download.htm
2. http://www.imada.sdu.dk/ svalle/courses/dm14-2005/mirror/c/
3. http://www.enggnotebook.weebly.com/uploads/2/2/7/1/22718186/ge6151-notes.pdf

MOOC Course:

1. https://www.alison.com/courses/Introduction-to-Programming-in-c
2. http://www.ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-s096-effective-programming-in-c- and-c-january-iap-2014/index.htm

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	**Topics to be covered**	**CO's**	**Reference T1: 4.1**
1-2	Introduction to Computers: computer systems, computing environments, Computer languages, creating and running programs	CO 1	T2: 1.1-1.2
3-4	Algorithms, flowcharts; Introduction to C language: Computer languages, History of C, basic structure of C programs, process of compiling and running a C program	CO 2	T2: 2.1-2.2
5-6	C tokens, keywords, identifiers, constants, strings	CO 2	T2: 1.4-1.5
7-8	Special symbols, variables, data types	CO 3	T2:2.1-2.2
9-10	Operators and expressions	CO 3	T2: 2.3-2.6,7
11-12	Simple if, if-else, else if ladder, Nested if and Case Statement-switch statement	CO 3	T2:3.1-3.5
13-14	While, for and do while loops	CO 5	T2: 5.2-5.3
15–16	Jump statements, break, continue, goto statements	CO 7	T2: 6.1-6.6

17–18	Concepts, one dimensional arrays, declaration and initialization of one-dimensional arrays	CO 9 4	T2: 6.7
19–20	Two dimensional arrays, initialization and accessing	CO 13	T2: 8.1-8.3
21-22	Multi-dimensional arrays; Strings: Arrays of characters	CO 13	T2: 11.1-11.5
23-24	Variable length character strings, inputting character strings, character library functions, string handling functions	CO 15	T2: 4.1-4.5
25	Need for user defined functions, function declaration, function prototype	CO 15	T1:7 T2: 6.9
26	Category of functions, inter function communication, function calls	CO 11	T1:10T2:10
27	Parameter passing mechanisms, recursion, passing arrays to functions, passing strings to functions,	CO 16	T2:10.3-10.5
28	Storage classes, preprocessor directives	CO 16	T1:8.9
29	Structure definition, initialization, accessing structures, nested structures	CO 16	T2: 12.3-12.4
30	Unions, C programming examples, BitFields, typedef, enumerations	CO 16	T2:12.4
31-32	Arrays of structures, structures and functions, passing structures through pointers, self-referential structures	CO 17	T2:2.1-2.2
33-34	Unions, bit fields, typedef, enumerations	CO 17	T2: 2.3-2.6,7
35–36	Pointer basics, pointer arithmetic, pointers to pointers, generic pointers, array of pointers, pointers and arrays	CO 19	T2: 5.2-5.3
37	Pointers as functions arguments, functions returning pointers	CO 19	T2: 5.2-5.3
38	Dynamic memory allocation: Basic concepts, library functions	CO 20	T2: 6.1-6.6
39	Streams, basic file operations, file types, file opening modes, input and output operations with files	CO 20	T2:10.4
40-41	Special functions for working with files, file positioning functions	CO 21	R3:12.1-12.3
42	Command line arguments. Searching	CO 22	R3:12.4
43	Sorting algorithms bubble, insertion, selection	CO 23	T2:11.4 R7:13.1
44-45	Algorithm complexity through example programs	CO 23	T2:11.4 R7:13.1
44-45	Algorithms and Flowcharts	CO 1	T2:2.1-2.2, R4:1.4
	Operators, Precedence and Associativity of Operators, Expression Evaluation	CO2	T2:2.3-2.6,
46-46	Simple if, if-else, else if ladder, Nested if and Case Statement-switch statement	CO 2	T2:3.1-3.5

47-48	While, for and do while loops, Jump statements, break, continue, goto statements	CO 3	T2:5.2-5.3,T2:6.1-6.6
48-49	One dimensional arrays	CO 3	T2: 8.1-8.2, R4:15.1
50-51	Strings and its operations	CO 3	T2: 8.3, R4: 15.1
51-52	User defined Functions, Parameter passing mechanisms, passing arrays to functions, passing strings to functions,	CO 4	T1:10, T2:10.1 10.2, T2:10.3-10.4, R4:8.3-8.5
52-53	Recursion	CO 4	T2:10.5
54-55	Pointer basics, pointer arithmetic, pointers to pointers, generic pointers, array of pointers, pointers and arrays Pointers as functions arguments, functions returning pointers, Dynamic Memory Allocation	CO 4	T2:3.1,R4:11
56-57	Storage classes, pre-processor directives	CO 5	T2:6.1-6.6
58-59	Structure definition, initialization, accessing structures	CO 5	T1:8.9,T2:2.3-2.5
60-61	Unions, bit fields, typedef, enumerations, command line arguments	CO 5	T2: 12.3-12.4,R4:13.4
61-62	File Handling	CO 6	T2:10.4,R4
62-63	Introduction	CO 1,2	T2:1.1-1.5,T2:2.1
63-64	Control Structures	CO 3	T2: 3.1 –3.5, T2:5.2 – 5.3
65-66	Arrays and Functions	CO 4	T2: 8.1 –8.3, R4:15.1
67-68	Pointer and Structures	CO 5	T2: 12.3–12.4,R4: 13.2–13.4,T1: 8.9
69-70	File Handling and Applications In C	CO 6	T2: 10.4,T2: 14.1– 14.4
71-72	Module I	CO 1,2	T2:1.1-1.5,T2:2.1-2.6

73-74	Module II	CO 3	T2: 3.1 –3.5, T2:5.2 – 5.3
75-76	Module III	CO 4	T2: 8.1 –8.3, R4:15.1
77-78	Module IV	CO 5	T2: 12.3–12.4,R4: 13.2–13.4,T1: 8.9
79-80	Module V	CO 6	T2: 10.4,T2: 14.1– 14.4

Signature of Course Coordinator **HOD,CSE**
Mr. P Ravinder Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTOR

Course Title	**ENGINEERING PHYSICS CHEMISTRY LABORATORY**					
Course Code	AHS104					
Program	B.Tech					
Semester	I	EEE				
Course Type	Foundation					
Regulation	IARE – R16					
Course Structure	**Theory**			**Practical**		
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**	
	3	1	4	3	2	
Course Coordinator	Mr.G Mahesh Kumar					

I. COURSE OVERVIEW:

This lab provides hands on experience in a number of experimental techniques and develops competence in the instrumentation typically used in physics. This laboratory includes experiments involving basic principles of interference diffraction, optoelectronic devices, magnetism. Engineering Chemistry laboratory is to develop the analytical ability of the students by better understanding the concepts experimental chemistry. The experiments carried out like conductometry, potentiometry, physical properties of liquids. After completing this course, students will be well prepared for the advanced laboratory.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
10 + 2	-	-	Basic Principles of Physics and Chemistry

III. MARKSDISTRIBUTION:

Subject	SEE Examination	CIAExamination	Total Marks
Engineering Physics and Chemistry Laboratory	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✔	Chalk & Talk	✘	Quiz	✘	Assignments	✘	MOOCs
✔	LCD / PPT	✘	Seminars	✘	Mini Project	✔	Videos
✔	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the Principal from the panel of experts recommended by Chairman, BOS.

The emphasis on the questions is broadly based on the following criteria:

20 %	To test the preparedness for the experiment.
20 %	To test the performance in the laboratory.
20 %	To test the calculations and graphs related to the concern experiment.
20 %	To test the results and the error analysis of the experiment.
20 %	To test the subject knowledge through viva – voce.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Table 1: Assessment pattern for CIA

Component	**Theory**		**Total Marks**
Type of Assessment	Day to day performance	Final internal lab assessment	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Preparation	**Performance**	**Calculations and Graph**	**Results and Error Analysis**	**Viva**	**Total**
2	2	2	2	2	10

VI. COURSE OBJECTIVES :

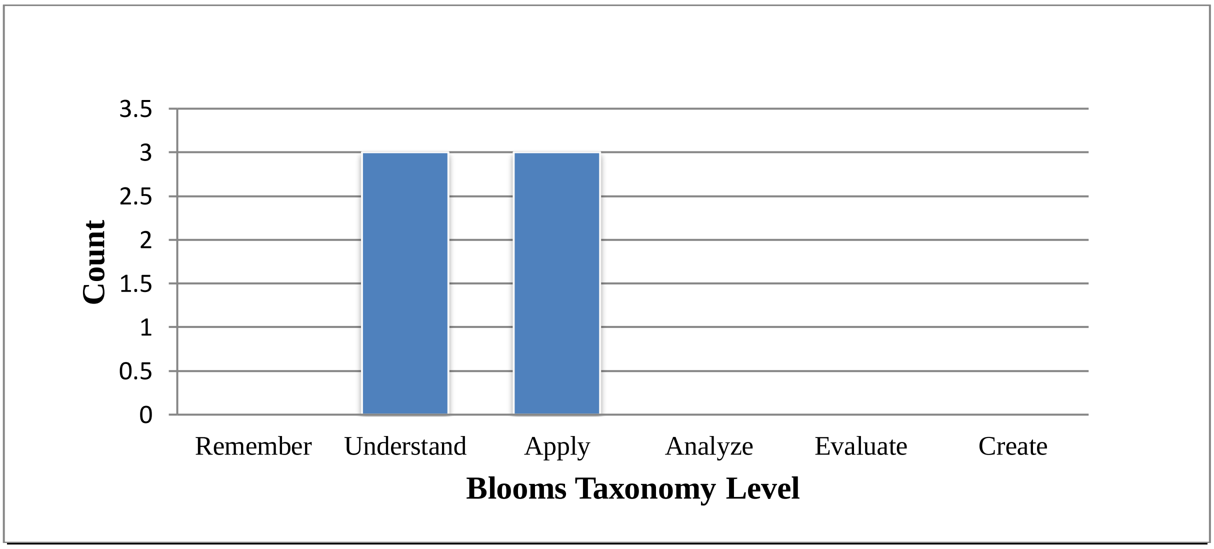
The students will try to learn:	
I	Develop skills to impart measurement technology, usage of new instruments and real time applications of physics in engineering studies.
II	Understand principle, working and application of theoretical concepts by comparison of results with experimental calculations.
III	The basic principles involved in instrumentation, preparations and measurement of physical properties.
IV	The need and importance of quality of water for industrial and domestic use.

VII. COURSE OUTCOMES:

After successful completion of the course, students will be able to:

	Course Outcomes	Knowledge Level (Bloom's Taxonomy)
CO 1	**Illustrate** the functioning of optoelectronic devices like LED and solar cellfrom Voltage/Light vs. current characteristics.	Understand
CO 2	**Apply** practical knowledge of RC circuit, semiconductor physics and optical fiber communication**in real time application**	Apply
CO 3	**Explore**magnetic induction in a current loop**with the help of Tangent's law.**	Understand
CO 4	**Identify**the total hardness, dissolved oxygen in waterbyvolumetric analysis for finding the hardness causing salts in water.	Apply
CO 5	**Make use of**conductometric and potentiometric titrations for finding the concentration of unknown solutions.	Apply
CO 6	**Explain** the importance of different types of materials for understanding their composition and applications.	Understand

COURSE KNOWLEDGE COMPETENCY LEVELS



VIII. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineeringfundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/CIE
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complexengineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	1.5	SEE/CIE
PO 4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	SEE/CIE

3 = High; 2 = Medium; 1 = Low

IX. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.	1	Laboratory experiments
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	1	Laboratory experiments
PSO 3	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.	-	-

3 = High; 2 = Medium; 1 = Low

X. MAPPING OF EACH CO WITH PO(s), PSO(s):

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	√	√	-	-	-	-	-	-	-	-	-	-	√	-	-
CO 2	√	√	-	√	-	-	-	-	-	-	-	-	√	-	-
CO 3	√	-	-	√	-	-	-	-	-	-	-	-	-	-	-
CO 4	√	√	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	√	√	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-

XI. JUSTIFICATIONS FOR CO – PO/PSO MAPPING –DIRECT

Course Outcomes	POs / PSOs	Justification for mapping (Students will be able to)	No. of key competencies
CO 1	PO 1	**Explain** the V-I characteristics of light emitting diode with different colors of LEDs for different threshold voltage values.	3
	PO 2	Understand the phenomenon of recombination of electron-hole pair and determine the value of threshold voltage of a given LED	4
	PSO 1	**Make use of the** knowledge of intrinsic and extrinsic semiconductors in the design and development ofelectrical systems.	1
CO 2	PO 1	**Explain** functionality of components in optical fibercommunication system by using the basics of signalpropagation, attenuation and dispersion.	3
	PO 2	**Understand**the given problem and formulateexpressions for acceptance angle and numerical aperturewith the given information and data by applyingprinciples of information propagation through opticalwave guides.	4
	PO 4	**Identify** the use of optical fibers in modern communication system for the research-based knowledge and technological development.	2
	PSO 1	**Make use of** the knowledge of optical fiber communication system in the development of modern communication systems.	1
CO 3	PO 1	**Explain** the variation of magnetic field at various points along the axis of current carrying coil and make use of mathematical expression of Tangent's law using Stewart Gee's apparatus.	2
	PO 4	**Understand** the given problem statement of current loop and formulate magnetic field induction at various points along the axis of current loop from experimental collection of information and data in reaching substantial conclusions by the interpretation of results.	4
CO 4	PO 1	**Demonstrate** the total hardness, dissolved oxygen in water by volumetric analysis for finding the hardness causing salts in waterby applying**mathematical** expressionsby using **principles of science** for solving**engineering** problems.	3
	PO 2	**Identify the problem** and formulate for finding the hardness of water in terms of CaCO3 equivalents with given **information and data** by applying principles of science.	2
CO 5	PO 1	**Choose** different electrodes for finding pH of unknown solutions by applying **mathematical** expressions of cell potential by using **principles of science** for solving **engineering** problems.	3
	PO 2	**Identify** the problem **formulation and abstraction** for calculatingthe concentration of unknown solutions by applying normality of standard solution from the provided **information.**	2
CO 6	PO 1	**Explain** the mechanism of chemical reactions for synthesizing drug molecules, synthetic rubbers, composition of materialsand different types of liquids for finding the surface tension and viscosity of lubricantsby applying**mathematical** expressions by using **principles of science** for solving**engineering** problems.	3

XII. TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/PSO MAPPING

Course Outcomes	Program Outcomes / No. of Key Competencies Matched												PSOs/ No. of key competencies		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
	3	10	10	11	1	5	3	3	12	5	12	12	2	2	2
CO 1	3	4	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 2	3	4	-	2	-	-	-	-	-	-	-	-	1	-	-
CO 3	3	-	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-

XIII. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO/PSO):

Course Outcomes	Program Outcomes / No. of key competencies												PSOs / No. of key competencies		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
	3	10	10	11	1	5	3	3	12	5	12	12	2	1	2
CO 1	100	40	-	-	-	-	-	-	-	-	-	-	30	-	-
CO 2	100	40	-	18	-	-	-	-	-	-	-	-	30	-	-
CO 3	100	-	-	18	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	20.0	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	100	20.0	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-

XIV. COURSE ARTICULATION MATRIX (PO – PSO MAPPING)

COs and POs and COs and PSOs on the scale of 0 to 3, **0** being **no correlation**, **1** being the **Low correlation**, **2** being **medium correlation** and **3** being **high correlation**.

0 – **0**$\leq C \leq$ 5%–Nocorrelation

1 – 5 <$C \leq$ 40%– Low/ Slight

2 − 40 % <C< 60% –Moderate

3 – 60% ≤ C< 100% – Substantial /High

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	2	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 2	3	2	-	1	-	-	-	-	-	-	-	-	1	-	-
CO 3	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	6	-	-	-	-	-	-	-	-	-	-	-	-	-
AVERAGE	3	1.5	-	1	-	-	-	-	-	-	-	-	1	-	-

XV. ASSESSMENT METHODOLOGY - DIRECT

CIE Exams	✔	SEE Exams	✔	Assignments	-	Seminars	-
Laboratory Practices	✔	Student Viva	✔	Mini Project	-	Certification	-
Term Paper	--						

XVI. ASSESSMENT METHODOLOGY - INDIRECT

✗	Early Semester Feedback	✔	End Semester OBE Feedback
✗	Assessment of Mini Projects by Experts		

XVII. SYLLABUS

LIST OF EXPERIMENTS	
Week-l	**INTRODUCTION TO PHYSICS/CHEMISTRY LABORATORY**
Introduction to physics/chemistry laboratory. Do's and Don'ts in physics/chemistry laboratory.	
Week-2	**PHY: DISPERSIVE POWER - SPECTROMETER, CHE: VOLUMETRIC ANALYSIS**

Batch I: Dispersive power of material of prism. Batch II: Estimation of hardness of water by EDTA method.	
Week-3	**CHE: VOLUMETRIC ANALYSIS, PHY: DISPERSIVE POWER - SPECTROMETER**
Batch I: Estimation of hardness of water by EDTA method. Batch II: Dispersive power of material of prism.	
Week-4	**PHY: STEWART GEE'S METHOD, CHE:VOLUMETRIC ANALYSIS**
BatchI: Magnetic field along the axis of current carrying coil-Stewart and Gee's method. Batch II: Estimation of dissolved oxygen in water by Winkler's method.	
Week-5	**CHE:VOLUMETRIC ANALYSIS, PHY: STEWART GEE'S METHOD**
Batch I: Estimation of dissolved oxygen in water by Winkler's method. Batch II: Magnetic field along the axis of current carrying coil-Stewart and Gee's method.	
Week-6	**PHY: LASER - DIFFRACTION GRATING, CHE: INSTRUMENTATION**
Batch I: Determination of wavelength of a given laser light using diffraction grating. Batch II: Conductometric titration of strong acid vs strong base.	
Week-7	**CHE: INSTRUMENTATION, PHY: LASER - DIFFRACTION GRATING**
Batch I: Conductometric titration of strong acid vs strong base. Batch II: Determination of wavelength of a given laser light using diffraction grating.	
Week-8	**PHY: OPTICAL FIBER, CHE: INSTRUMENTATION**
Batch I: Evaluation of numerical aperture of given fiber. Batch II:. Potentiometric titration of strong acid vs strong base.	
Week-9	**CHE: INSTRUMENTATION, PHY: OPTICAL FIBER**
Batch I:. Potentiometric titration of strong acid vs strong base. Batch II: Evaluation of numerical aperture of given fiber.	
Week-10	**PHY: NEWTON'S RINGS, CHE: PHYSICAL PROPERTIES**
Batch I: Newton's rings-Radius of curvature of plano convex lens. Batch II: Determination of surface tension and viscosity of lubricants	
Week-11	**CHE: PHYSICAL PROPERTIES, PHY: NEWTON'S RINGS**
Batch I: Determination of surface tension and viscosity of lubricants Batch II: Newton's rings-Radius of curvature of plano convex lens.	
Week-12	**PHY: PLANCK'S CONSTANT, CHE: PREPARATION OF ORGANIC COMPOUNDS**

Batch I: Determination ofPlanck's constantusing LED. Batch II: Preparation of Aspirin and Thiokol rubber.	
Week-13	**CHE: PREPARATION OF ORGANIC COMPOUNDS, PHY: PLANCK'S CONSTANT**
Batch I: Preparation of Aspirin and Thiokol rubber. Batch II: Determination ofPlanck's constantusing LED.	
Week-14	**REVISION**
Revision.	
References:	
1. C. L. Arora, "Practical Physics", S. Chand & Co., New Delhi, 3rd Edition, 2012. 2. Vijay Kumar, Dr. T. Radhakrishna, "Practical Physics for Engineering Students", S M Enterprises, 2nd Edition, 2014. 3. Vogel's, "Quantitative Chemical Analaysis", Prentice Hall, 6th Edition, 2000. 4. Gary D.Christian, "Analytical Chemistry", Wiley Publications, 6th Edition, 2007.	
Web Reference:	
http://www.iare.ac.in	

XVIII. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Week No	Topics to be covered	Course Outcomes	Text (T) book / Reference (R) book
1	Introduction to physics/chemistry laboratory. Do's and Don'ts in physics/chemistry laboratory.	CO 1, CO 4	R3,R4
2	Estimation of hardness of water by EDTA method	CO 4	R3,R4
3	Estimation of hardness of water by EDTA method.	CO 4	R3,R4
4	Estimation of dissolved oxygen in water by Winkler's method.	CO 4	R3,R4
5	Estimation of dissolved oxygen in water by Winkler's method.	CO 4	R3,R4
6	Conductometric titration of strong acid vs strong base.	CO 5	R3,R4
7	Conductometric titration of strong acid vs strong base.	CO 5	R3,R4
8	Potentiometric titration of strong acid vs strong base.	CO 5	R3,R4
9	Potentiometric titration of strong acid vs strong base.	CO 5	R3,R4
10	Determination of surface tension and viscosity of lubricants	CO 6	R3,R4
11	Determination of surface tension and viscosity of lubricants	CO 6	R3,R4
12	Preparation of Aspirin and Thiokol rubber.	CO 6	R3,R4

Week No	Topics to be covered	Course Outcomes	Text (T) book / Reference (R) book
13	Preparation of Aspirin and Thiokol rubber.	CO 6	R3,R4
14	Revision of all the experiments	CO 1, CO 6	R3,R4

Prepared by
Mr.G Mahesh Kumar **HOD, EEE**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COMPUTER SCIENCE AND ENGINEERING

COURSE DESCRIPTION

Course Title	**PROGRAMMING FOR PROBLEM SOLVING LABORATORY**				
Course Code	ACS101				
Program	B.Tech				
Semester	I	CSE |IT |ECE |EEE |MECH |AERO			
Course Type	Foundation				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Mr,Ravinder, Assistant Professor				

I COURSE OVERVIEW:

The course covers the basics of programming and demonstrates fundamental programming techniques, customs and terms including the most common library functions and the usage of the preprocessor. This course helps the students in gaining the knowledge to write simple C language applications, mathematical and engineering problems. This course helps to undertake future courses that assume this programming language as a background in computer programming. Topics include variables, data types, functions, control structures, pointers, strings, arrays and dynamic allocation principles. This course in reached to student by power point presentations, lecture notes, and lab involve the problem solving in mathematical and engineering areas..

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	ACSB02	II	-

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Computer Programming Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

I	The hands on experience in design, develop, implementation and evaluation by using Asymptotic notation.

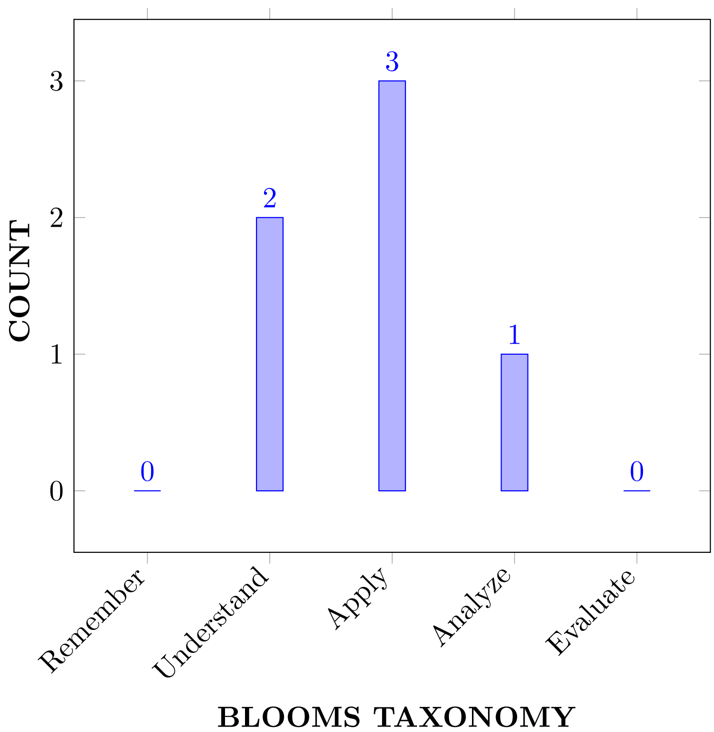
II	The demonstration knowledge of basic abstract data types (ADT) and associated algorithms for organizing programs into modules using criteria that are based on the data structures of the program.
III	The practical implementation and usage of non linear data structures for solving problems of different domain.
IV	The knowledge of more sophisticated data structures to solve problems involving balanced binary search trees, AVL Trees, B-trees and B+ trees, hashing.
V	The graph traversals algorithms to solve real-world challenges such as finding shortest paths on huge maps and assembling genomes from millions of pieces

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Demonstrate** problem solving steps in terms of algorithms, pseudocode and flowcharts for Mathematical and Engineering problems. .	Understand
CO 2	**Make use** the concept of operators, precedence of operators, conditional statements and looping statements to solve real time applications.	Apply
CO 3	**Demonstrate** the concept of pointers, arrays and perform pointer arithmetic, and use the pre-processor.m.	Understand
CO 4	**Analyze** the complexity of problems, modularize the problems into small modules and then convert them into programs.	Apply
CO 5	**Implement** the programs with concept of file handling functions and pointer with real time applications of C.	Apply
CO 6	**Explore** the concepts of searching and sorting methods with real time applications using c	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:**Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Viva-voce/Laboratory Practices
PO 2	**Problem analysis:**Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Viva-voce/Laboratory Practices
PO 3	**Design/development of solutions:**Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	Viva-voce/Laboratory Practices
PO 5	**Modern Tool Usage:**Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	2	Viva-voce/Laboratory Practices
PO 10	**Communication:**Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Viva-voce/Laboratory Practices
PO 12	**Life-long learning:**Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	Viva-voce/Laboratory Practices

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	**Professional Skills:** The ability to research, understand and implement computer programs in the areas related to algorithms, system software, multimedia, web design, big data analytics, and networking for efficient analysis and design of computer-based systems of varying complexity. .	2	Viva-voce Laboratory Practices

PSO 2	**Software Engineering Practices:** The ability to apply standard practices and strategies in software service management using open-ended programming environments with agility to deliver a quality service for business success .	2	Viva-voce Laboratory Practices
PSO 3	**Successful Career and Entrepreneurship:** The ability to employ modern computer languages, environments, and platforms in creating innovative career paths, to be an entrepreneur, and a zest for higher studies. .	2	Viva-voce Laboratory Practices

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	**Justification for mapping (Students will be able to)**	No. of Key Competencies
CO 1	PO 1	Understand (knowledge) the basic concept of algorithm analysis which provides theoretical estimates for the resources needed by any algorithm for a given computational problem. These estimates provide an insight into reasonable directions of search for efficient algorithms by applying the principles of **mathematics and science**	3
	PO 5	Understand the (given **knowledge**) appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	3
CO 2	PO 1	Understand (knowledge)the basic concept of algorithm analysis which provides theoretical estimates for the resources needed by any algorithm for a given computational problem. These estimates provide an insight into reasonable directions of search for efficient algorithms by applying the principles of **mathematics and science.**	3
	PO 5	Understand the (**knowledge**) appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	2
CO 3	PO 1	Understand (**knowledge**) the basic concept of algorithm analysis which provides theoretical estimates for the resources needed by any algorithm for a given computational problem. These estimates provide an insight into reasonable directions of search for efficient algorithms by applying the principles of **mathematics and science.**	3
	PO 5	Understand the (knowledge) appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	3

CO 4	PO 1	Describe (knowledge) the use sorting techniques as a basic building block in algorithm design and problem solving **using principles of mathematics, science, and engineering fundamentals.**	3
	PO 5	Understand the **knowledge** appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	2
	PO 10	Apply (knowledge) concept of dimensional analysis and similarity parameters for predicting physical parameters (understanding) for the fluid flow analysis used in designing prototypes devices (apply) solving design problems by applying the **communicating effectively with engineering community.**	3
CO 5	PO 1	Outline the importance of searching algorithms to retrieve an element from any data structure where it is stored by **understanding and applying the fundamentals of mathematics, science and engineering.**	3
	PO 10	Understand the use of searching techniques that retrieve information stored within some data structure by **communicating effectively with engineering community**.	2
CO 6	PO 1	Outline the importance of searching algorithms to retrieve an element from any data structure where it is stored by **understanding and applying the fundamentals of mathematics, science and engineering**	2
	PO 10	Understand the use of searching techniques that retrieve information stored within some data structure by **communicating effectively with engineering communit.**	3
CO 7	PO 1	Make use of linear data structures to organize the data in a particular way so to use them in the most effective way by applying the **basic knowledge of mathematics, science, engineering fundamentals**	2
	PO 2	Build strong foundation of data Structures which tells the program how to store data in memory and forming some relations among the data and use them in **design and development of new products.**	2
	PO 3	Recognize the need of linear data structures such as linked list, array, stack and queue by **designing solutions for complex Engineering problems** in real-time.	1
	PSO 1	Acquire sufficient knowledge to develop real-time applications by making use of linear data structures in (**career building and higher studies.**	3
CO 8	PO 1	Describe (knowledge) the usage of data structures in organizing, managing, and storing different data formats that enables efficient access and modification by applying the **fundamentals of mathematics, science, and engineering.**	3

	PO 5	(**Modern Tool Usage:**)Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	
	PO 3	Understand the applications of basic data structures such as stacks, queues, linked lists in (**designing and developing solutions of complex engineering applications.**	4
	PSO 1	Make use of modern computer tools for applying the basic data structure concepts in building real-time applications for a successful career.	
CO 9	PO 1	Apply the sophisticated hierarchical data structures to organize keys in form of a tree to use in many real-life applications by **using the principles of mathematics and engineering fundamentals.**	3
	PO 2	Make use of non-linear data structures such as balanced trees in by **identifying, formulating and analyzing complex engineering problems** such as databases, syntax tree in compilers and domain name servers etc. **with the help of basic mathematics and engineering sciences**.	3
	PO 3	Extend the concept of tree data structures to **design and develop solutions for complex engineering problems**.	3
	PSO 1	Make use of modern computer tools in implementing non-linear data structures for various applications to become a successful professional in the domain.	3
CO 10	PO 1	Demonstrate different tree structures in Python to implement real-time problems by **applying basic knowledge of science and engineering fundamentals.**	3
	PO 2	Illustrate the importance of tree data structures used for various applications **by identifying, formulating and analyzing complex engineering problems** such as operating systems and compiler design.	3
	PO 3	Make use of tree data structures to **design and develop solutions for complex engineering problems** and which is the key organizing factor in software design. Data structures can be used to organize the storage and retrieval of information stored in both main memory and secondary memory.	3
	PSO 1	Acquire sufficient knowledge in field of data structures and its applications by using modern computer tools so that new product development can take place, which leads to become successful entrepreneur and or to obtain higher education.	3

CO 11	PO 1	Understand (knowledge) the benefits of dynamic and static data structures implementations and choose appropriate data structure for specified problem domain **using knowledge of mathematics, science and engineering fundamentals.**	3
	PO 2	Recognize the need of dynamic and static data structures **in identifying, formulating and analyzing complex engineering problems.**	3
	PO 3	Describe (knowledge) the usage of static and dynamic data structures in designing solutions for complex Engineering problems.	3
	PSO 1	Build sufficient knowledge of dynamic data structures by using modern tools so that new product can be developed, which leads to become successful entrepreneur in the present market.	3
CO 12	PO 1	Build strong foundation of quickly determining the efficiency of an algorithm or data structure for solving computing problems with respect to performance by using knowledge of mathematics, science and engineering fundamentals.	3
	PO 2	Recognize the importance of suitable data structures in checking the efficiency of algorithms used for complex engineering problems.	3
	PO 3	Make use of broad usage of data structures in designing and developing of complex engineering applications.	3
	PSO 1	Extend the concept of data structures in solving complex engineering problems using modern engineering tools to become a successful professional in the domain.	3

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES PO 1	PROGRAM OUTCOMES				
	PO 2	PO 3	PO 5	PO 10	PSO 1
CO 1	3			2	
CO 2	3			2	
CO 3	3			2	3
CO 4	3			2	2
CO 5	2				2
CO 6	3				2
CO 7	3	2	2		2
CO 8	3		3	2	2
CO 9	2	2	3		2
CO 10	2	3	2		2

CO 11	3	2	2		2
CO 12	2	2	3		3

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1, ,PO 2, PO 3, PSO 1	SEE Exams	PO 1,PO 3, PO 5, PSO 1	Seminars	-
Laboratory Practices	PO 1,PO 2, PO 3, PO 5,PO 10, PSO 1	Student Viva	PO 1, PO 5	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**SEARCHING TECHNIQUES**
	Write python program for implementing the following searching techniques. a. Linear search. b. Binary search. c. Fibonacci search.
WEEK II	**SORTING TECHNIQUES**
	Write Python programs for implementing the following sorting techniques to arrange a list of integers in ascending order. a. Bubble sort. b. Insertion sort. c. Selection sort.
WEEK III	**SORTING TECHNIQUES**
	Write Python programs for implementing the following sorting techniques to arrange a list of integers in ascending order. a. Quick sort. b. Merge sort.
WEEK IV	**IMPLEMENTATION OF STACK AND QUEUE**
	Write Python programs to a. Design and implement Stack and its operations using Lists. b. Design and implement Queue and its operations using Lists
WEEK V	**APPLICATIONS OF STACK**
	Write Python programs for the following: a. Uses Stack operations to convert infix expression into postfix expression. b. Uses Stack operations for evaluating the postfix expression. .
WEEK VI	**IMPLEMENTATION OF SINGLE LINKED LIST**

	Write Python programs for the following: a. Uses functions to perform the following operations on single linked list. (i) Creation (ii) insertion (iii) deletion (iv) traversal b. To store a polynomial expression in memory using linked list. .
WEEK VII	**IMPLEMENTATION OF CIRCULAR SINGLE LINKED LIST**
	Write Python programs for the following: Uses functions to perform the following operations on Circular linked list. (i) Creation (ii) insertion (iii) deletion (iv) traversal .
WEEK VIII	**IMPLEMENTATION OF DOUBLE LINKED LIST**
	Write Python programs for the following: Uses functions to perform the following operations on double linked list. (i) Creation (ii) insertion (iii) deletion (iv) traversal in both ways .
WEEK IX	**IMPLEMENTATION OF STACK USING LINKED LIST**
	Write Python programs to implement stack using linked list.
WEEK X	**MPLEMENTATION OF QUEUE USING LINKED LIST**
	Write Python programs to implement queue using linked list
WEEK XI	**GRAPH TRAVERSAL TECHNIQUES**
	Write Python programs to implement the following graph traversal algorithms: a. Depth first search. b. Breadth first search.
WEEK XII	**IMPLEMENTATION OF BINARY SEARCH TREE**
	Write a Python program that uses functions to perform the following: a. Create a binary search tree. b. Traverse the above binary search tree recursively in pre-order, post-order and in-order. Count the number of nodes in the binary search tree.

TEXTBOOKS

1. Sutton, G.P., et al., —Rocket Propulsion Elements, John Wiley Sons Inc., New York, 1993

2. Martin J.L Turner , Rocket Space Craft Propulsion, Springers oraxis publishing, 2001

REFERENCE BOOKS:

1. Mathur, M., and Sharma, R.P., —Gas Turbines and Jet and Rocket Propulsion, Standard Publishers, New Delhi 1998

2. Cornelisse, J.W., Rocket Propulsion and Space Dynamics, J.W., Freeman & Co. Ltd., London, 1982.

3. Parker, E.R., Materials for Missiles and Spacecraft, McGraw-Hill Book Co. Inc., 1982.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Calibration of Venturimeter and Orifice meter.	CO 1	R1: 1.2
2	Determination of pipe flow losses in rectangular and circular pipes.	CO 2	R2: 3.5
3	Verification of Bernoulli‘s theorem	CO 3	R1: 3.4
4	Determination of Reynolds Number of fluid flow	CO 4	R1: 2.2

5	Determine the reaction forces produced by the change in momentum.	CO 5	R1: 2.4
6	Determine the efficiencyand draw theperformance curves ofcentrifugal pump.	CO 6	R3: 4.5
7	Determine the efficiencyand draw theperformance curves of reciprocating pump.	CO 6	R3: 4.6
8	Determine the performance characteristics of pelton wheel under constant head.	CO 6	R2: 5.1
9	Determine the performance characteristics of Francis turbine.	CO 6	R2: 5.2
10	Determine the rate of flow through weir.	CO 7	R1: 7.1
11	Determine the rate of flow through Nothches.	CO 7	R1:7.2
12	Determine the rate of flow through a Orifice meter	CO 7	R1:7.3

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Twin vortex formation:** Demonstration of twin vortex formation and calculation of vortex size for different geometries.
2	**Open channel:** Demonstration of streamline at different angle of attack and calculation of separation point for different Reynolds number.
3	**Capillary action:** By modeling capillary action using two cups of water and a paper towel, you'll gain a better understanding of the importance of this process in trees.
4	**Buoyancy** Calculation of meta center and displacement volume for various geometries and materials.
5	**Flow through pipes:** Encourage students to design and analyze flow through pipes using ANSYS

Signature of Course Coordinator **HOD,AE**
Mr. P Ravinder, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRONICSENGINEERING

COURSE DESCRIPTION

Course Title	**COMPUTATIONAL MATHEMATICS LABORATORY**				
Course Code	AHS102				
Program	B.Tech				
Semester	I	EEE			
Course Type	Foundation				
Regulation	IARE- R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Ms. B Praveena, Assistant Professor				

I COURSE OVERVIEW:

II. The aim of this course is to know about the basic principles of Engineering Mathematics and itsapplication in MATLAB by means of software. Nowadays the principles of MATLAB find widerange of applications in many situations such as signal processing and communications, imageandvideoprocessing,controlsystems,testandmeasurement,computationalfinance,andcomputational biology. Using MATLAB, one can analyze data, develop algorithms, and createmodelsandapplications.

II COURSE PRE-REQUISITES:

Level	**Course Code**	**Semester**	**Prerequisites**
10 + 2	-	-	Basic Principles of Algebra and Calculus

III MARKS DISTRIBUTION:

Subject	**SEE Examination**	**CIE Examination**	**Total Marks**
Computational-MathematicsLaboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

I	DemonstratethebasicprinciplesofMATLAB.
II	Analyze the applications of Algebraand Calculus using MATLAB software.
III	Estimate the roots of Algebraic and Transcendental equations..

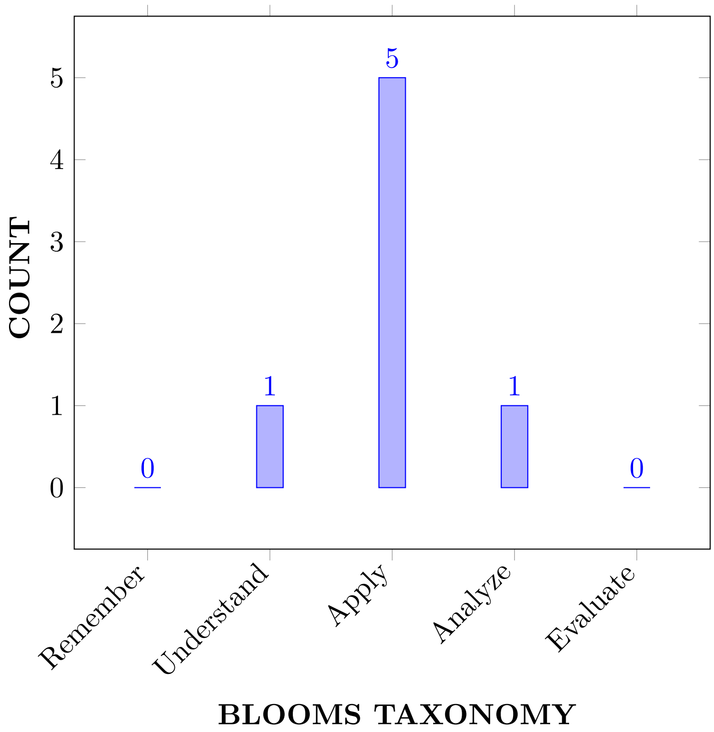
IV	Evaluate the characteristics of given curves bymeans of plottingagraph.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Solve** the algebraic and transcendental equations with in given range rangeusing MAT LAB programs. .	Apply
CO 2	**Utilize** MAT LAB programs for verifying properties of limits,derivatives of a function.	Apply
CO 3	**Interpret** rank,eigen values and vectors with matrix transformations.	Understand
CO 4	**Utilize** MAT LAB programs for solving differential equations and multiple integrals.	Apply
CO 5	**Make use of** of MAT LAB programs for interpolating values of differential equations numerically.	Apply
CO 6	**Use** MAT LAB programs for vector operations on vector field.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program	Strength	Proficiency Assessed by

PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises
PO 2	**Problem analysis:** Problem analysis: Identify, formulate, review research literature, and analyze complexengineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	CIA
PO 4	**Conduct investigations of complex problems:**Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	ProfessionalSkills:To produce engineering professiona lcapable of synthesizing and analyzing mechanical systems including allied engineering streams	1	Presentation on real-world problems

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	**Justification for mapping (Students will be able to)**	No. of Key Competencies
CO 1	PO 1	Utilize the concept of calibration to a considerable extent appreciate (understanding) their importance and applicability (apply) in solving (complex) fluid flow engineering problems by applying the **principles of Mathematics and Engineering**	3
	PO 2	Identify (given **problem statement**)MAT LAB commands for synthesizing and analyzing the given data (provided **information and data**) by principles of Mathematics.	4
	PO 4	Apply (given **problem statement**)MAT LAB commands for analyzing the given data **information and data**) by using various algebraic functions numerically.	2

	PSO 1	Apply (**knowledge**) properties, various types and patterns of fluid flow configurations (apply) for solving design problems by applying the **in various engineering streams following mathematical rules and conditons.**	1
CO 2	PO 1	Identify (understanding) the appropriate MAT LAB programs for verifying limitsand derivatives of the givenfunctions and Understand the major role of these functions which exists as solutions **for integrals and differential equations of elementary functions by applying the principles of mathematics.**	3
	PO 2	Identify (given **problem statement**) the given problem and formulate MAT LAB program for solving and make use of mathematical method **information**to facilitate physical interpretation of the results obtained.	4
	PO 4	Apply (given **problem statement**) the given problem and formulate MAT LAB program for solving and make use of mathematical method MAT LABcommands for synthesizing and analyzing the given data **information**in various engineering streams following mathematical rules and conditons.	2
	PSO 1	Apply (knowledge) MAT LAB commands for synthesizing and analyzing the given data **in various engineering streams following mathematical rules and conditons.**	1
CO 3	PO 1	Interpret (**knowledge**) the rank and inverse of real and complex matrices using MAT LAB programs.	3
	PO 2	Apply **problem statement** MAT LAB program for decomposing the given matrix for (**complex**) solving complex engineering problems following principles ofmathematics. **results**.	4
	PO4	Apply (knowledge) MAT LAB programfor finding Eigen values and Eigen vectors along **with basic principles of mathematics to develop the solution.**	2
	PSO 1	Apply (knowledge)MAT LAB commands for synthesizing and analyzing the given data **in various engineering streams following mathematical rules and conditons.**	1
CO 4	PO 1	Identify (knowledge) appropriate MAT LAB programsforfinding length of the curves and area of the surfacefor with respect to **the fundamental operations of arithmetic(knowledge) for majority of functions by principlesofMathematics.**	3
	PO 2	Interpret **problem statement and formulate** the suitable MAT LAB program for solving double and triple integral in the given region.	2
	PSO 1	Apply (knowledge) MAT LAB commands for synthesizing and analyzing the given data in various engineering streams	1

CO 5	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals**the knowledge of MAT LAB programs. toSolve the algebraic and transcendental equations numerically with in given range .	3
	PSO 1	Apply **problem statement** MAT LAB commands for synthesizing and analyzing the given data in various engineering streams following mathematical rules and conditons.	1
CO 6	PO 1	Develop **Mathematics and Engineering fundamentals** the formulation of differential calculus of complex engineering problems which transforms vector functions, gradient, Divergence and curl using principle of mathematics to the realworld engineering problems by using MAT LAB programs.	3
	PO 2	Apply **principles of Sciences and Engineering fundamentals** the formulation of integral transformations to complex engineering problems related to surface and volume, line and surface of different geometrical models using principle of mathematics in the domain of engineering to reach conclusions by interpretation of results.	2
	PSO 1	Apply **understand the innovative and dynamic challenges** MAT LAB commands for synthesizing and analyzing the given data in various engineering streams following mathematical rules and conditons.	1

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES			PSO'S
	PO 1	PO 2	PO 4	PSO 1
CO 1	3	2	1	1
CO 2	3	2	1	1
CO 3	3	2	1	1
CO 4	3	1	-	1
CO 5	3	-	-	1
CO 6	3	1	-	1

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1, PO 3, PSO 3	SEE Exams	PO 1,PO 3, PO 5, PSO 3	Seminars	-
Laboratory Practices	PO 1,PO 3, PO 5, PSO 3	Student Viva	PO 1, PO 5	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**BASIC FEATURES**
	To Know the history and features of MATLAB, To Know the loca lenvironment of MATLAB
WEEK II	**ALGEBRA**
	Solving basic algebraic equations, Solving system of equations, Two dimensional plots.
WEEK III	**CALCULUS**
	Calculating limits, Solving differential equations, Finding definite integral.
WEEK IV	**MATRICES**
	Addition,subtraction and multiplication of matrices, Transpose of a matrix, Inverse of a matrix.
WEEK V	**SYSTEMOF LINEAREQUATIONS**
	Rank of a matrix, Gauss Jordan method, LU decomposition method.
WEEK VI	**LINEARTRANSFORMATION**
	Characteristic equation, Eigen values, Eigen vectors.
WEEK VII	**DIFFERENTIATIONANDINTEGRATION**
	a. Higher order differential equations, Double integrals, Triple integrals.
WEEK VIII	**INTERPOLATION AND CURVEFITTING**
	Lagrange polynomial, Straight linefit, Polynomial curve fit.
WEEK IX	**ROOT FINDING TECHNIQUES**
	Bisection method, Regulafalsemethod, NewtonRaphsonmethod.
WEEK X	**NUMERICAL DIFFERENTION AND INTEGRATION**
	Trapezoidal, Simpson‘smethod, Eulermethod, RungeKuttamethod.
WEEK XI	**3D PLOTTING**
	Line plotting, Surfaceplotting Volumeplotting.
WEEK XII	**VECTORCALCULUS**
	Gradient, Divergent, Curl.

TEXTBOOKS

1. 1. Dean G.Duffy, Advanced Engineering Mathematics with MATLAB, CRC Press,Taylorand Francis Group,6thEdition,NewDelhi,2015.

REFERENCE BOOKS:

1. 1.Cleve Moler,Numerical Computing with MATLAB,SIAM,Philadelphia,2ndEdition,2008.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Understanding thebasic featuresof MATLAB.	CO 1	T1:1.1 R1:2.21
2	Determination of roots of agiven polynomial.	CO 1	T1:15.1 R1:2.25
3	Verification of basic properties of limits.	CO 2	T1:2.1 R1:2.21
4	Determination ofrank,inverse,transpose and obtaining the solution to linear system of equationsofamatrix.	CO 3	T1-15.6 R1:2.32
5	Interpret the Eigen values and Eigenvectors of a matrix.	CO 3	T1:15.5 R1:2
6	Determination of derivatives and integration toa Given function.	CO 4	T1:2.1 R1:2.8
7	Determination of bestfit curve to the given data	CO 6	T1:3.0 R1:2.9
8	Calculation of areaenclosed bounded bya region.	CO 4	T1:14.5 R1:5.1
9	Solving the higher order differential equations.	CO 4	T1:3.1 R1:5.21
10	Plotting agiven surface bounded in a region.	CO 4	T1:14.3-14.8 R1:5.1
11	Determination of gradient,divergence and cur of avector. .	CO 5	T1:14.2 R1:2.2
12	Determination of roots to algebraic and transcendental equations by bisection method, Method of false position and Newton-Raphson method	CO 6	T1:2.2 R1:2.25

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Algebraic equations:** Apply MAT LAB programs to algebraic equations
2	**Differentiation:** Apply MAT LAB programs differential equations and matrices .
3	**Matrices:** Apply MAT LAB programs to eigen values and eigen vectors.
4	**Numerical methods** Apply MAT LAB programs to numerical methods
5	**Vector calculus:** Apply MAT LAB programs to vector calculus

Signature of Course Coordinator **HOD,EEE**
Ms. B Praveena, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**ENGLISH FOR COMMUNICATION**				
Course Code	AHS001				
Program	B. Tech				
Semester	I				
Course Type	Foundation				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	-	2	-	-
Course Coordinator	Dr. Jetty Wilson, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-
-	-	-	-
-	-	-	-

II COURSE OVERVIEW:

The principle aim of the course is that the students will have awareness about the importance of English language in the contemporary times and also it emphasizes the students to learn this language as a skill (listening skill, speaking skill, reading skill and writing skill). Moreover, the course benefits the students how to solve their day-to-day problems in speaking English language. Besides, it assists the students to reduce the mother tongue influence and acquire the knowledge of neutral accent. The course provides theoretical and practical knowledge of English language and it enables students to participate in debates about informative, persuasive, didactic, and commercial purposes.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
English	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	LCD / PPT	x	Chalk & Talk	x	Assignments	x	MOOC
✓	Open Ended Experiments	✓	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), and 10 marks for Alternative Assessment Tool (AAT).

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
37%	Remember
63 %	Understand
-	Apply
-	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
	Continuous Internal Examination – 2 (Mid-term)	10	
	AAT-1	5	
	AAT-2	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			100

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

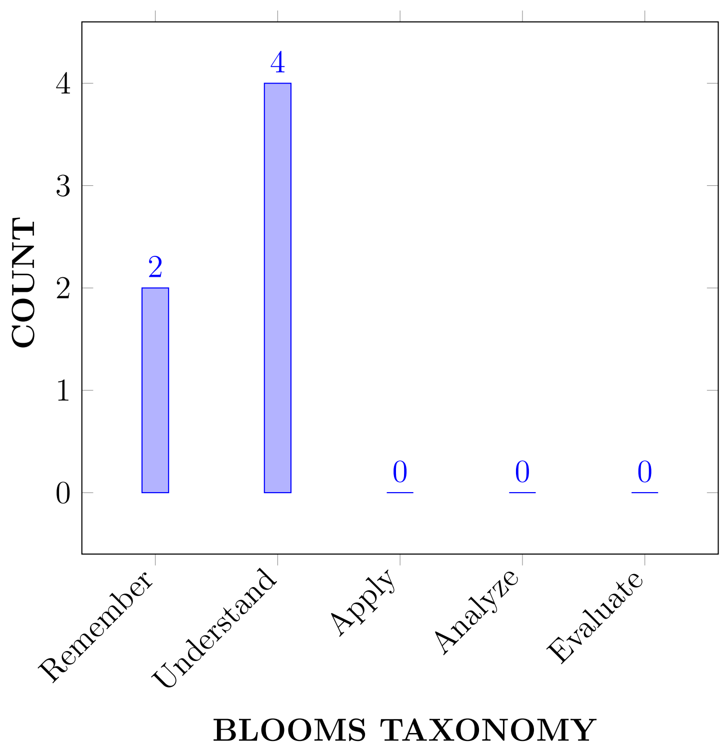
I	Communicate in an intelligible English pronunciation to meet the global standards.
II	Effectively use of four language skills (listening skill, speaking skill, reading skill and writing skill) in day-to-day affairs.
III	A critical aspect of speaking and reading for interpreting in-depth meaning between the sentences.
IV	Develop the art of writing in English keeping the standards of reader's understanding levels.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Describe** that Listening skills are essential to leadership which is useful in the real-world situations.	Remember
CO 2	**Illustrate** appropriate speaking strategies such as keeping the discussion going, turn-taking, asking for clarification or confirmation, paraphrasing, keeping the discussion on topic, and trying to reach a consensus.	Understand
CO 3	**Define** the value of English as a Lingua-Franca and recall the knowledge in soft skills for the perfect language usage.	Understand
CO 4	**Explain** the effective usage of functional English grammar and lexical items at academic and non-academic platforms.	Remember
CO 5	**Understand** the importance of critical reading to catch on the in-depth meaning of a written text at various levels of professional career.	Understand
CO 6	**Demonstrate** the role of written communication as a key aspect to meet the academic and professional challenges.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 10	**Communication :** Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (Communication). "Students should demonstrate the ability to communicate effectively in writing / Orally." 1. Clarity (Writing); 2. Grammar/Punctuation (Writing); 3. References (Writing); 4. Speaking Style (Oral); 5. Subject Matter (Oral).	5	Seminar/ Conferences/ Research Papers IE/AAT / Discussion

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Understand, analyze, design and supervise sub-structures and superstructures for residential and public buildings, industrial structures, irrigation structures, powerhouses, highways, railways, airways, docks and harbors.	-	-
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	-	-
PSO 3	Make use of advanced software for creating modern avenues to succeed as an entrepreneur or to pursue higher studies.	-	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 2	-	-	-	-	-	-	-	-	-	✓-	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 3	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Discuss the heeds of functional grammar and punctuation tools in speaking and writing by generating the clarity of an audio text.	5
CO 2	PO 10	Illustrate essential aspects of grammar as well as punctuation marks for speaking or writing towards a discussion on a topic to give the clarity.	5
CO3	PO 10	Choose suitable grammatical structures and punctuation marks at speaking and writing areas maintaining clarity at professional platform.	5
CO4	PO 10	Interpret the grammatical knowledge and punctuation marks systematically towards providing the clarity in speaking and writing.	5
CO5	PO 10	Demonstrate the role of grammar and punctuation marks understanding the meaning between the sentences as well as paragraphs in speaking or writing for a clarity.	5
CO6	PO 10	Describe the clarity of grammatical usage and the obligation of punctuation marks in speaking and writing.	5

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 2	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 4	-	-	-	-		-	-	-	-	5	-		-	-	-
CO 5	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	5	-		-	-	- -

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	-	-	100	-		-	-	-
CO 2	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-
CO 3	-		-	-	-	-	-	-	-	100	-	-	-	-	-
CO 4	-	-	-	-		-	-	-	-	100	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	100	-	-	- -	-	-
CO 6	-	-	-	-		-	-	-	-	100	-		-	-	- -

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	-	-	3	-	-	-	-	
CO 2	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
TOTAL	-	-	-	-	-	-	-	-	-	18	-	-	-	-	-
AVERAGE	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**GENERAL INTRODUCTION AND LISTENING SKILL**
	Introduction to communication skills; Communication process; Elements of communication; Soft skills vs. hard skills; Importance of soft skills for engineers; Listening skills; Significance; Stages of listening; Barriers and effectiveness of listening; Listening comprehension.
MODULE II	**SPEAKING SKILL**
	Significance; Essentials; Barriers and effectiveness of speaking; Verbal and non-verbal communication. Generating talks based on visual prompts; Public speaking; Exposure to structured talks; Addressing a small group or a large formal gathering; Oral presentation; Power point presentation.
MODULE III	**VOCABULARY AND GRAMMAR**
	The concept of Word Formation; Root words from foreign languages and their use in English; Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives; Synonyms; Antonyms; Standard abbreviations; Idioms and phrases; One-word substitutes Sentence structure; Uses of phrases and clauses; Punctuation; Subject verb agreement; Modifiers; Articles; Prepositions.
MODULE IV	**READING SKILL**
	Significance, Techniques of reading, Skimming-Reading for the gist of a text, Scanning - Reading for specific information, Intensive, Extensive reading, Reading comprehension, Reading for information transfer, Text to diagram, Diagram to text.
MODULE V	**WRITING SKILL**
	Significance; Effectiveness of writing; Organizing principles of Paragraphs in documents; Writing Introduction and conclusion; Techniques for writing precisely, Letter writing; Formal and Informal letter writing, E-mail writing, Report Writing.

TEXTBOOKS

1. Handbook of English (Prepared by the faculty of English, IARE).

REFERENCE BOOKS:

1. 1. Norman Whitby, Business Benchmark: Pre-Intermediate to Intermediate – BEC Preliminary, Cambridge University Press, 2nd Edition,2008.
2. Devaki Reddy, Shreesh Chaudhary, Technical English, Macmillan, 1st Edition,2009.
3. Rutherford, Andrea J, Basic Communication Skills for Technology, Pearson Education,2nd Edition, 2010.
4. Raymond Murphy, Essential English Grammar with Answers, Cambridge University Press, 2nd Edition,2010.
5. Dr. N V Sudershan, President Kalam's Call to the Nation, Bala Bharathi Publications, Secunderabad, 1st Edition,2003

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Discussion on mapping COs with POs. (OBE)		
CONTENT DELIVERY (THEORY)			
2	Introduction to communication skills.	CO 1	T1:06.06
3	Communication process.	CO 1	T1:06.09
4	Soft skills vs hard skills.	CO 3	T1:09.10
5	Significance of LSRW skills.	CO 1	T1:10.11
6	Significance of listening skill.	CO 1	TI:12.16
7	Different stages of listening.	CO 1	T1:16.18
8	Barriers of listening skill.	CO 1	TI:18.21
9	Different types of listeners.	CO 1	TI:21.22
10	Effectiveness of listening skill.	CO 1	T1:22.24
11	Phonetics: Listening to the sounds of English language.	CO 1	T1:24.29
12	Introduction to speaking skills.	CO 2	T1:30.32
13	Effectiveness of speaking skills.	CO 2	T1:33.34
14	Verbal and non-verbal communication.	CO 2	T1:34.35
15	Generating talks based on visual or written prompts.	CO 2	T1:36.37
16	Developing public speaking skills.	CO 2	T1:38.39
17	Oral presentation with power-point.	CO 3	TI:39.42
18	The concept of word formation.	CO 4	T1:43.100
19	Antonyms and synonyms.	CO 4	TI:49.56
20	Idioms and phrases.	CO 4	TI:57.60
21	One-word substitutes.	CO 4	TI:60.62
22	Root words from foreign languages and their usage in English.	CO 4	TI:60.62
23	Sentence structure.	CO 4	T1:58.62
24	Punctuation tools and their role in a language.	CO 4	TI:63.66
25	Subject-verb agreement.	CO 4	TI:66.69
26	Usage of Adjectives.	CO 4	TI:70.73
27	Significance of articles and their usage	CO 4	TI:74.75
28	The usage of prepositions.	CO 4	T1:76.77
29	Significance of reading skill.	CO 5	T1:78.79
30	Different techniques of reading skill.	CO 6	T1:80.82
31	How to Read Your Textbook More Efficiently.	CO 6	TI:83.85
32	Different types of reading comprehension.	CO 6	TI:85.86
33	Reading for information transfer.	CO 6	TI:85.96
34	Significance and effectiveness of writing skill.	CO 6	TI:96.98

35	Organizing principles of a paragraph in documents and types of paragraphs.	CO 5	T1:101.103
36	Writing introduction and conclusion.	CO 5	T1:103.103
37	Techniques for writing precis.	CO 8	T1:103.103
38	Introduction to informal letters.	CO 7	TI:105.108
39	Introduction to formal letters.	CO 7	TI:109.110
40	Introduction of email writing and formal and informal emails.	CO 7	TI:111.112
41	Significance of Report Writing.	CO 8	TI: 113. 114
PROBLEM SOLVING/ CASE STUDIES			
42	The aspects to improve listening comprehension Discuss in detail.	CO 1	TI:10,11
43	Different types of listeners with examples	CO 1	TI: 19,21
44	The sounds of English language	CO 1	TI:23,27
45	verbal communication or written communication.	CO 2	TI: 27,30
46	Various difficulties in public speaking.	CO 2	TI: 32,33
47	Different ways of greeting people in formal and informal situation and discuss how do they matter in communication?	CO 2	TI: 35,37
48	'Oral presentation requires a good planning'.	CO 2	TI:36,38
49	Power point presentation and the ways to make Power point presentation.	CO 2	TI: 37,38
50	Methods that are used to establish the process of building vocabulary with examples from the most used words in spoken English.	CO 4	TI:39,41
51	The usage of idioms and phrases in spoken English.	CO 4	TI: 47,50
52	'Structure proposition-evaluation' -Reading technique.	CO 5	TI:56,58
53	Active reading, detailed reading, and speed-reading techniques used in different situations.	CO 5	TI: 79,81
54	The elements of paragraph writing in detail.	CO 8	TI:100,102
55	Logical bridges and Verbal bridges in writing.	CO 8	TI:102,104
56	Soft skills and Interpersonal Communication.	CO 8	TI:102,104
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Soft skills and Interpersonal Communication.	CO 1	TI 8,9
58	Language acquisition is a process.	CO 1	TI: 11,12
59	Communication.	CO 1	TI: 14,16
60	Time management.	CO 3	TI:9,10
61	Stress management.	CO 3	TI:9,10
DISCUSSION OF QUESTION BANK			
62	Soft Skills for difficult situations in terms of reassurance and reliability.	CO 3	TI:9,10
63	Verbal and non-verbal communication.	CO 2	TI: 34,35
64	Honesty, Respect, Self-Control and Accountability their role in building long lasting interpersonal skills?	CO 3	TI: 9,10
65	Etiquette and manners. Its importance in social, personal and professional communication.	CO 23	TI: 9,10

66	Problem solving and decision making.	CO 3	TI: 9,10

Signature of Course Coordinator **HOD**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**MATHEMATICAL TRANSFORM TECHNIQUES**				
Course Code	AHS011				
Program	B. Tech				
Semester	II				
Course Type	Foundation				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Ms. Dr.S.Jagadha, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSB02	I	Linear Algebra and Calculus
B.Tech			
B.Tech			

II COURSE OVERVIEW:

The course focuses on more advanced engineering mathematics topics which provide with the relevant mathematical tools required in the analysis of problems in engineering and scientific professions. The course includes types of matrices, difference calculus methods and differential equations. The mathematical skills derived from this course form a necessary base to analytical and design concepts encountered in the program.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Mathematical Transform Techniques	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with

"either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
30%	Understand
60 %	Apply
%	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

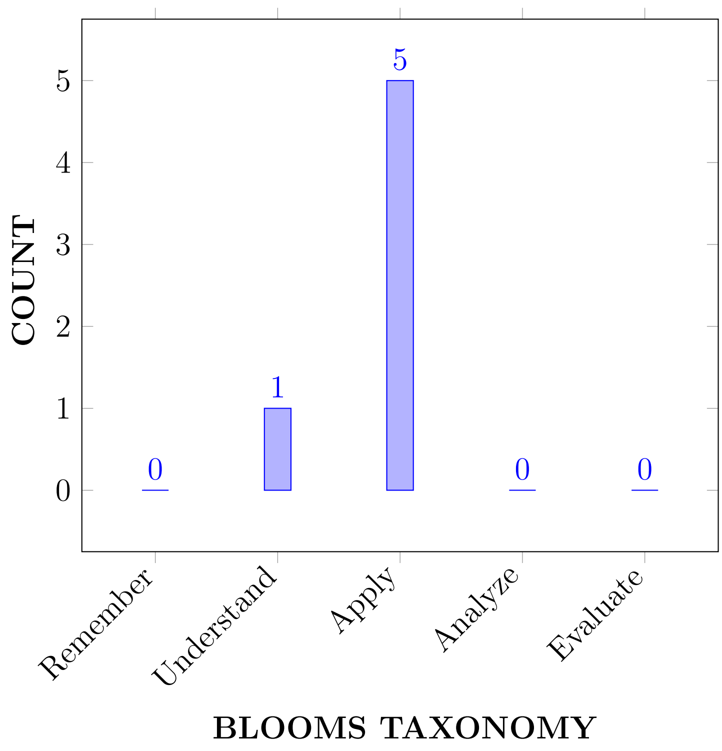
I	The operation of non-periodic functions by Fourier transforms.
II	The transformation of ordinary differential equations in Laplace field and its applications
III	Z-transforms to solve the difference equations
IV	The partial differential equation for solving non-linear equations

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the nature of the Fourier series that represent even and odd functions.	Understand
CO 2	**Apply** to compute the Fourier series of the function with one variable.	Apply
CO 3	**Identify** the role of Fourier transform non-periodic functions up to infinity as a mathematical function in transforming a signal from the time domain to the frequency domain	Apply
CO 4	**Explain** the properties of Laplace and inverse transform to various functions the integral transforms operations of calculus to algebra in linear differential equations	Apply
CO 5	**Compute** the Z-transforms and inverse of Z-transforms to difference equations by using the methods of partial fractions and convolution method.	Apply
CO 6	**Solve** the linear, nonlinear partial differential equation by the method of Lagrange's ,separiable and Charpit to concern engineering field	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Program Outcomes	
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.	2	Seminar/ Conferences/ Research Papers
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	-	-
PSO 3	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.	-	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	✓	-	-	-	-	-	-	-	-	✓	-	-
CO 4	✓	-	-	-		-	-	-	-	-	-		-	-	-
CO 5	-	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 6	✓	✓	-	-		-	-	-	-	-	-	-	-	-	

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Explain** the Fourier Series to the periodic functions for solving complex engineering problems of various functions such as continuous, piecewise continuous, step and impulsive functions with **principle of mathematics.**	2
CO 2	PO 1	**Apply** the Fourier series (understand) to complex engineering problems of various functions such as continuous, piecewise continuous, step and impulsive functions with principle of mathematics.	2
CO3	PO 1	**Identify** the mathematical function as a signal form from the time domain to the frequency domain in the **complex engineering problems** by (apply) Fourier transformation. **Principle of Mathematics**	2
	PO 2	**Apply** the Fourier integral transform as a **formulation** of mathematical function in **complex engineering problems** which transforms a non-periodic functions using **principles of mathematics** to attain conclusions by the **interpretation of results**	4
	PO4	Explain the integral transforms in solving ordinary differential equations will be **quantitatively measured** by using **MATLAB computer software**.	1
	PSO1	Describe the integral transforms concern Mechanical Engineering (apply) which converts operations of calculus to algebra in solving linear differential equations **in the design and implementation of complex systems.**.	1
CO4	PO 1	**Explain** the properties of Laplace and inverse transform (understand) to **complex engineering problems** of various functions the integral transforms operations of calculus to algebra in linear differential equations with **principle of mathematics**	2
CO5	PO2	**Compute** the statement of the Z-transforms and inverse of Z-transforms in **complex engineering problems** which difference equations by using the methods of partial fractions and convolution method using **principle of mathematics** related to engineering by **the interpretation of results**.	4
	PSO 1	**Compute** the properties of complex Z transform concern Mechanical Engineering which intensifies (apply) the boundary value problems in **the design and implementation of complex systems**.	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO6	PO1	**Solve** the linear, nonlinear partial differential equation related to **complex engineering problems** such as the method of Lagrange's ,separable and Charpit to the physical problems of engineering **Principle of Mathematics**	2
	PO2	**Solve** the **statement and formulation** of Lagrange's linear equation (understand) related to **complex engineering problems**, solutions are attained based on **principles of mathematics** to the physical problems of engineering by **the interpretation of results**	4

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	4	-	1	-	-	-	-	-	-	-	-	1	-	-
CO 4	2	-	-	-		-	-	-	-	-	-		-	-	-
CO 5	-	4	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 6	2	4	-	-	-	-	-	-	-	-	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.7	40	-	9	-	-	-	-	-	-	-	-	50	-	-
CO 4	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	40	-	-	-	-	-	-	-	-	-	-	50	-	-
CO 6	66.7	40	-	-		-	-	-	-	-	-		-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	1	-	-	-	-	-	-	-	-	2	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	15	6	-	1	-	-	-	-	-	-	-	-	4	-	-
AVERAGE	3	2	-	1	-	-	-	-	-	-	-	-	2	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	-
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester OBE Feedback	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**FOURIER SERIES**
	Definition of periodic function, determination of Fourier coefficients; Fourier expansion of periodic function in a given interval of$length 2\pi$; Fourier series of even and odd functions; Fourier series in an arbitrary interval; Half- range Fourier sine and cosine expansions.
MODULE II	**FOURIER TRANSFORMS**
	Fourier integral theorem, Fourier sine and cosine integrals; Fourier transforms; Fourier sine and cosine transform, properties, inverse transforms, finite Fourier transforms.
MODULE III	**LAPLACE TRANSFORMS**
	Definition of Laplace transform, linearity property, piecewise continuous function, existence of Laplace transform, function of exponential order, first and second shifting theorems, change of scale property, Laplace transforms of derivatives and integrals, multiplied by t, divided by t, Laplace transform of periodic functions. Inverse Laplace transform: Definition of Inverse Laplace transform, linearity property, first and second shifting theorems, change of scale property, multiplied by s, divided by s; Convolution theorem and applications.
MODULE IV	**Z –TRANSFORMS**
	Z-transforms: Elementary properties, inverse Z-transform, convolution theorem, formation and solution of difference equations.
MODULE V	**PARTIAL DIFFERENTIAL EQUATIONS AND APPLICATIONS**

	Formation of partial differential equations by elimination of arbitrary constants and arbitrary functions, solutions of first order linear equation by Lagrange method; Charpit's method; method of separation of variables; One dimensional heat and wave equations under initial and boundary conditions.

TEXTBOOKS

1. B.S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 36thEdition, 2010.
2. N.P. Bali and Manish Goyal, "A text book of Engineering Mathematics", Laxmi Publications, Reprint, 2008.
3. Ramana B.V., "Higher Engineering Mathematics", Tata McGraw Hill New Delhi, 11th Reprint,2010.

REFERENCE BOOKS:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons, 9thEdition, 2006.
2. Veerarajan T., "Engineering Mathematics for first year", Tata McGraw-Hill, New Delhi, 2008.
3. D. Poole, "Linear Algebra: A Modern Introduction", Brooks/Cole, 2ndEdition, 2005.
4. Dr. M Anita, "Engineering Mathematics-I", Everest Publishing House, Pune, First Edition, 2016

WEB REFERENCES:

1. http://www.efunda.com/math/math_home/math.cfm
2. http://www.ocw.mit.edu/resourcs/#Mathematics
3. http://www.sosmath.com
4. http://www.mathworld.wolfram.com

COURSE WEB PAGE:

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Introduction to outcome based education		
CONTENT DELIVERY (THEORY)			
2	Define periodic function	CO 1	T1:22.5 R1:2.3
3	Solve Fourier coefficients	CO 1	T1:22.5 R1:2.4
4	Apply Fourier series for $(0, 2\pi)$	CO 1	T1:22.6 R1:2.6

5	Determine even and odd function	CO 2	T1:22.7 R1:4.4
6	Determine Fourier series in (0,2l), (-l,l) and also half range series in (0, l)	CO 1	T1:22.7 R1:4.10
7	Determine half range series in $(0, \pi)$	CO 2	T1:22.8 R1:4.15
8	Apply Fourier integral theorem to find integrals	CO 2	T1:22.9 R1:5.4
9	Apply Fourier sine and cosine integrals to find integrals	CO 3	T1:22.9 R1:5.8
10	Define and apply Fourier transforms	CO 3	T1:23.10 R1:6.8.
11	Use properties to solve the given functions	CO 3	T1:23.10 R1:6.13
12	Define and apply Inverse transforms	CO 3	T1:23.9 R1:7.5
13	Define and apply Finite Fourier transforms	CO 3	T1:23.10 R1:7.5
14	Define Laplace transform and its property	CO 4	T1:23.10 R1:8.1
15	Define piecewise continuous function	CO 4	T1:23.1 R1:9.2
16	Define and apply shifting theorem, change of scale property	CO 4	T1:23.1 R1:9.4
17	Solve derivatives and integrals, multiplied by t,divided by t	CO 74	T1:23.1 R1:9.9
18	Define periodic functions	CO 4	T1:23.1 R1:9.10
19	Solve Inverse Laplace transform	CO 4	T2:27.5 R1:10.2
20	Define and apply shifting theorem	CO 4	T2:27.7 R1:11.3
21	Solve multiplied by s, divided by s	CO 4	T2:27.8 R1:11.6
22	Define change of scale property	CO 4	T2:27.7 R1:11.3
23	Divided by s Define Z-transforms, Elementary properties	CO 5	T2:27.12 R1:11.8
24	Change of scale property Define inverse Z-transform	CO 5	T2:27.12 R1:11.9
25	Define inverse Z-transform	CO 5	T2:27.12 R1:11.10
26	Formulate partial differential equations	CO 6	T2:27.14 R1:12.3
27	Solving difference equations by Z transforms	CO 5	T2:27.1 R1:12.7
28	Solve by Charpit's method	CO 6	T2:27.17 R1:12.15

29	Apply method of separation of variables	CO 6	T2:18.2 R1:13.1
30	Define inverse Z-transform	CO 5	T2:18.3-18.5 R1:13.2 , 13.3
31	Elementary properties	CO 5	T1:17.1-17.2 R1:16.1-16.2
32	Elimination of arbitrary constants(Formation of PDE)	CO 6	T1:17.1-17.2 R1:16.1-16.2
33	Elimination of arbitrary functions(Formation of PDE)	CO 6	T1:17.5-17.6 R1:16.3.1
34	Non-Linear Partial differential equation of first order (Standard forms I, II ,III and IV)	CO 6	T1:17.1-17.2 R1:16.1-16.2
35	Non-Linear Partial differential equation of first order Standard forms V	CO 6	T1:17.5-17.6 R1:16.3.1
36	Non-Linear Partial differential equation	CO 6	T1:17.1-17.2 R1:16.1-16.2
37	Non-Linear Partial differential equation of first order Standard forms VI	CO 6	T1:17.1-17.2 R1:16.1-16.2
38	Lagrange's Linear equation- Method of grouping	CO 6	T1:17.5-17.6 R1:16.3.1
39	Lagrange's Linear Equation -Method of Multipliers	CO 6	T1:17.1-17.2 R1:16.1-16.2
40	Elimination of arbitrary constants(Formation of PDE)	CO 6	T1:17.1-17.2 R1:16.1-16.2
41	Elimination of arbitrary functions(Formation of PDE)	CO 6	T1:17.5-17.6 R1:16.3.1
42	Non-Linear Partial differential equation of first order (Standard forms II)	CO 6	T1:17.5-17.6 R1:16.3.1-16.2

43	Non-Linear Partial differential equation of first order (Standard forms III)	CO 6	T1:17.5-17.6 R1:16.3.1-16.2
44	Non-Linear Partial differential equation of first order (Standard forms IV)	CO 6	T1:17.5-17.6 R1:16.3.1-16.2
PROBLEM SOLVING/ CASE STUDIES			
45	Solving problems on Fourier sine and cosine integral	CO 2	T1:17.1-17.2 R1:16.1-16.2
46	Solving problems on finite Fourier transforms	CO 3	T1:17.5-17.6 R1:16.3.1
47	Solving problems on Laplace Transform of First, second shifting theorems and change of scaleproperty	CO4	T1:17.1-17.2 R1:16.1-16.2
48	Solving problems on Inverse Laplace transforms of derivatives, integrals, multiplied by s, divided by s	CO 4	T1:17.5-17.6 R1:16.3.1
49	Solving problems on Convolution theorem	CO 4	T1:17.1-17.2 R1:16.1-16.2
50	Solving problems on Inverse Laplace transforms of derivatives, integrals, multiplied by s, divided by s	CO 4	T1:23.10 R1:8.1
51	Solving problems on Inverse Laplace transforms of derivatives, integrals, multiplied by s, divided by s	CO 4	T1:23.1 R1:9.2
52	Solving problems on first shifting theorems and change of scale property	CO 4	T1:23.1 R1:9.4
53	Solving problems on second shifting theorems and change of scale property	CO 4	T1:23.1 R1:9.9
54	Gauss divergence theorem	CO 4	T1:23.10 R1:8.1
55	Solving problems on formation of partial differential equations by elimination of arbitrary constants	CO 6	T1:17.1-17.2 R1:16.1-16.2
56	Solving problems on formation of partial differential equations by elimination of arbitrary functions	CO 6	T1:17.1-17.2 R1:16.1-16.2

DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Definitions and terminology on Fourier series	CO 1,2	T1:23.10 R1:6.8
58	Definitions and terminology on Fourier transforms	CO 3	T1:23.10 R1:7.5
59	Definitions and terminology on Laplace transforms	CO 4	T1:23.10 R1:8.1
60	Definitions and terminology on z transforms	CO 5	T2:27.12 R1:11.10
61	Definitions and terminology on partial differential equations	CO 6	T1:17.1-17.2 R1:16.1-16.2
DISCUSSION OF QUESTION BANK			
62	Desccsion of Fourier series	CO 1,2	T1:23.10 R1:8.1
63	Desccsion of Fourier transforms	CO 3	T1:23.10 R1:6.8
64	Desccsion of Laplace transforms	CO 4	T1:23.10 R1:7.5
65	Desccsion of z transforms	CO 5	T2:27.12 R1:11.10
66	Desccsion of partial differential equations	CO 6	T1:17.1-17.2 R1:16.1-16.2

Signature of Course Coordinator **HOD,EEE**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**CIVIL ENGINEERING**				
Course Title	**ENVIRONMENTAL STUDIES**				
Course Code	AHS009				
Program	B.Tech				
Semester	II				
Course Type	FOUNDATION				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr V Anitha Rani, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credit
10+2	-	-	Basic Principles of Science	-

II COURSE OVERVIEW:

Environmental study is interconnected interrelated and interdependent subject. Hence, it is multidisciplinary in nature. The present course is framed by expert committee of UGC under the direction of honorable supreme court to be as a core module syllabus for all branches of higher education and to be implemented in all universities over India. The course is designed to create environmental awareness and consciousness among the present generation to become environmental responsible citizens. The course description is multidisciplinary nature of environmental studies, natural resources Renewable and non-renewable resources Ecosystems Biodiversity and its conservation Environmental pollution Social issues and the environment Human population and the environment Pollution control acts and field work. The course is divided into five chapters for convenience of academic teaching followed by field visits.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Environmental Studies	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

x	Chalk & Talk	✓	Quiz	✓	Assignments	x	MOOC's
✓	LCD / PPT	✓	Seminars	x	Mini Project	✓	Videos
✓	Open Ended Experiments						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into five modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The emphasis on the questions is broadly based on the following criteria:

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
50%	Understand
50%	Apply
0 %	Analyze
0%	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 1), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz/AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc.

The AAT chosen for this course is given in section XI.

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

I	The interrelationship between living organism and environment.
II	The importance of environment by assessing its impact on the human world
III	The knowledge on themes of biodiversity, natural resources, pollution control and waste management.
IV	The constitutional protection given for the safety of environment.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the basic concept of environment, earths major cycle and its function related food chain, food web, and ecological pyramid for the importance of ecosystem and flow of energy in ecosystem	Understand
CO 2	**Classify** natural resource and necessity of natural resource conservationfor sustainable use and proper use.	Understand
CO 3	**Utilize** renewable and non-renewable energy resource for future growing energy needs.	Apply
CO 4	**Explain** the value of biodiversity hotspots, endangered and endemic species, in- situ and ex situ conservation methods for protecting the biodiversity.	Apply
CO 5	**Relate** the cause and effects of pollution related to Air, Water, Soil and Noise their control and treatment technologies.	Understand
CO 6	**Summarize** the concepts of Environmental Impact Assessment, global environmental problem, international summits, to minimize the problems towards sustainable future.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL

VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	CIE/Quiz/AAT
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	CIE/Quiz/AAT
PO 7	**Environment and sustainability:** understand the impact of the professional engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	3	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	**Professional Skills:** The ability to understand, analyze and develop computer programs in the areas related to algorithms, system software, multimedia, web design, big data analytics, and networking for efficient design of computer-based systems of varying complexity	-	-
PSO 2	**Problem-Solving Skills:** The ability to apply standard practices and strategies in software project development using open-ended programming environments to deliver a quality product for business success.	-	-
PSO 3	**Successful Career and Entrepreneurship:** The ability to employ modern computer languages, environments, and platforms in creating innovative career paths to be an entrepreneur, and a zest for higher studies.	-	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 2	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 4	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 5	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 6	✓	-	-	✓	-	-	✓	-	-	-	-	-	-	-	

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Explain the basic concept of environment, earths major cycle and its function related food chain, food web, and ecological pyramid for the importance of ecosystem and flow of energy in ecosystem by using principles of science for solving engineering problems.	2
	PO 7	Summarize about the toxicity of heavy metals on the biotic and abiotic components in in socio economic Environmental and politics contexts for Sustainable development.	3
CO 2	PO 1	Classify about different types of natural resources and their applicability and illustrate the utility of renewable resources efficiency by using principles of science for solving engineering problems.	2
	PO 7	Identify renewable and non renewable resources, Alternate energy resources and understand the impact in socio economic Environmental and politics contexts for Sustainable development.	3
CO3	PO 1	Explain the renewable and non renewable energy resource by using principles of science for solving engineering problems.	2
	PO 7	Utilize renewable and non renewable resources, Alternate energy resources and understand the impact in socio economic, politics and Environmental contexts for Sustainable development.	3
CO4	PO 1	Explain the fundamentals of Biodiversity and biotic resources, importance of biodiversity, the ecological values, India is mega diversity nation, the threats to biodiversity and importance of conservation of biodiversity by applying the principle of science for solving engineering problems.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 7	Demonstrate a comprehensive understanding of the world's biodiversity and the importance of its conservation, impact of biodiversity loss and National biodiversity act with the in socio economic, politics and Environmental contexts for Sustainable development.	3
CO5	PO 1	Relate the effect of pollutants on air, water and soil that causes the environmental pollution for solving engineering problems by applying the principles of science.	2
	PO 7	Explain the causes and effects of air pollution, water pollution, soil pollution and noise pollution and understand the impact in socio economic, politics and environmental contexts for sustainable development.	3
CO 6	PO 1	Explain the concepts of environmental impact assessment, global environmental problems, international summits, to minimize the problems towards sustainable future for solving engineering problems by applying the principles of science.	2
	PO 4	Recognize the methods and process of primary, secondary and tertiary treatment of waste water and understand the technology behind the pollution control devices.	2
	PO 7	Identify the environmental laws, population and its explosion green buildings in the context in socio economic, politics and Environmental contexts for Sustainable development.	3

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	3	-	-	-	-		-	-	-
CO 2	2	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 3	2	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 5	2	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 6	2	-	-	2	-	-	3	-	-	-	-	-	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.6	-	-	-	-	-	100	-	-	-	-	-	-	-	-
CO 2	66.6	-	-	-	-	-	100	-	-	-	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 3	66.6	-	-	-	-	-	100	-	-	-	-	-	-	-	-
CO 4	66.6	-	-	-	-	-	100	-	-	-	-	-	-	-	-
CO 5	66.6	-	-	-	-	-	100	-	-	-	-	-	-	-	-
CO 6	66.6	-	-	18	-	-	100	-	-	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 - $5 < C \leq 40\%$ – Low/ Slight
2 - $40\% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	3	-	-	-	-	-	-	-	
CO 2	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 6	3	-	-	1	-	-	3	-	-	-	-	-	-	-	-
TOTAL	18	-	-	1	-	-	18	-	-	-	-	-	-	-	-
AVERAGE	3	-	-	1	-	-	3	-	-	-	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓	Seminars	✓
Concept Video	-	Mini Project	-	Student Viva	-	Mini Project	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
x	Assessment of Mini Projects by Experts		

XVIII SYLLABUS:

MODULE I	**ENVIRONMENT AND ECOSYSTEMS**
	Environment: Definition, scope and importance of environment, need for public awareness; Ecosystem: Definition, scope and importance of ecosystem, classification, structure and function of an ecosystem, food chains, food web and ecological pyramids, flow of energy; Biogeochemical cycles Hydrological cycle, Phosphorous cycle, Nitrogen cycle. Biomagnifications.
MODULE II	**NATURAL RESOURCES**
	INatural resources: Classification of resources, living and nonliving resources; Water resources: Use and over utilization of surface and ground water, floods and droughts, dams, benefits and problems; Mineral resources: Use and exploitation; Land resources; Energy resources: Growing energy needs, renewable and non renewable energy sources, use of alternate energy source, case studies.
MODULE III	**BIODIVERSITY AND BIOTIC RESOURCES**
	Biodiversity and biotic resources: Introduction, definition, genetic, species and ecosystem diversity; Value of biodiversity: Consumptive use, productive use, social, ethical, aesthetic and optional values; India as a mega diversity nation; Endangered and Endemic species, Hot spots of biodiversity.Threats to biodiversity: Habitat loss, poaching of wildlife, human-wildlife conflicts; Conservation of biodiversity: In situ and ex situ conservation; National biodiversity act.
MODULE IV	**ENVIRONMENTAL POLLUTION, POLLUTION CONTROL TECHNOLOGIES AND GLOBAL ENVIRONMENTAL PROBLEMS**
	Environmental pollution: Definition, causes and effects of air pollution, water pollution, soil pollution, noise pollution; Solid waste: Municipal solid waste management, composition and characteristics of e-waste and its management; Pollution control technologies: Waste water treatment methods, primary, secondary and tertiary; Concepts of bioremediation; Global environmental problems and global efforts: Global Warming, Climate change, Sea level rise, ozone depletion, ozone depleting substances, deforestation and desertification; International conventions / protocols: Earth summit, Kyoto protocol and Montreal protocol.
MODULE V	**ENVIRONMENTAL LEGISLATIONS AND SUSTAINABLE DEVELOPMENT**
	Environmental legislations: Environmental protection act, air act1981, water act, forest act. municipal solid waste management and handling rules, biomedical waste management and handling rules2016, hazardous waste management and handling rules, Environmental impact assessment(EIA); Towards sustainable future: Concept of sustainable development, population and its explosion, crazy consumerism, environmental education, urban sprawl, concept of green building.

TEXTBOOKS

1. Benny Joseph, "Environmental Studies", Tata Mc Graw Hill Publishing Co. Ltd, New Delhi, 1st Edition, 2006.
2. Erach Bharucha, "Textbook of Environmental Studies for Under Graduate Courses", Orient Black Swan, 2nd Edition, 2013.
3. Dr. P. D Sharma, "Ecology and Environment", Rastogi Publications, New Delhi, 12th Edition, 2015.

REFERENCE BOOKS:

1. Tyler Miller, Scott Spoolman, "Environmental Science", Cengage Learning, 14th Edition, 2012.
2. Anubha Kaushik, "Perspectives in Environmental Science", New Age International, New Delhi.4th Edition, 2006.
3. Gilbert M. Masters, Wendell P. Ela, "Introduction to Environmental Engineering and Science, Pearson, 3rd Edition, 2007

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
1	Explain the scope and importance of Environment and need for Public Awareness	CO 1	T1:1.1.3 R1:2.1
2	Identify scope and importance of ecosystem	CO1	T1:1.1.4 R1:2.7.1
3	Explain Structure and function of ecosystem	CO1	T1:1.1.6 R1:2.7.4
4	Relate the Food chain food web and pyramids	CO1	T1:1.7.2 R1:2.15
5	Realate the Flow of energy	CO1	T1:1.7.2 R1:2.16
6	Explain the Biogeochemical cycles.	CO1	T1:1.7.6 R1:2.17
7	Interpret the Biomagnifications.	CO1	T1:1.7.3 R1:2.19
8	Classify the Living and non living resources	CO 2	T1:2.1 R1:2.21
9	Explain the Water resources: use and over utilization of surface and ground water	CO 2	T1:2.2.2 R1:2.3
10	Explain the Floods and Drought	CO 2	T1:2.2.4 R1:4.1

11	Relate dams: befit and problems	CO 2	T1:2.3.1 R1:4.3
12	Explain the Mineral resources: use and exploitation of minerals	CO 2	T1:2.4 R1:4.8
13	Relate the Energy resources and introduction and applications	CO 3	T1:2.5.2 R1:4.6
14	Explain the Wind energy and its application	CO 3	T1:2.5.3 R1:4.6
15	Explain Land resources	CO 2	T1:2.4 R1:4.8
16	Identify renewable and non renewable resources	CO 3	T1:2.5.3 R1:4.6
17	Recall the Biodiversity and Biotic introduction and definition.	CO 4	T1:3.1 R1:4.5
18	Relate the Classification of biodiversity	CO 4	T1:3.2.2 R1:4.8
19	Explain the Values of biodiversity	CO 4	T1:3.3.1 R1:4.7
20	Identify India is mega diversity nation	CO 4	T1:3.4 R1:4.9
21	Recognize Hot spots of biodiversity	CO 4	T1: 3.4 R1:4.10
22	Explain the Threats to biodiversity	CO 4	T1: 3.5 R1:1.10
23	Explain the Man wild life conflict	CO 4	T1:3.5.2 R1:1.10
24	Relate the Conservation of Biodiversity	CO 4	T1:3.7 R1:1.16
25	Recall National biodiversity act	CO 4	T1: 3.9 R1:1.16
26	Recall the Environmental pollution : Introduction and classification	CO 5	T1: 4.1 R1:1.16
27	Explain the Air pollution: primary and secondary pollutants, effects and its control	CO 5	T1: 4.2 R1:1.11
28	Explain the Water pollution: types effects and control of water pollution	CO 5	T1:4.6 R1:5.2
29	Explain the Soil pollution: sources effects and control of soil pollution	CO 5	T1: 4.8 R1:5.2
30	Explain the Noise pollution: sources effects and control of noise pollution	CO 5	T1: 4.13 R1:5.10
31	Explain the Municipal waste management	CO 5	T1: 4.16 R1:5.2.3
32	Explain the solid waste management	CO 5	T1:4.16.3 R1:5.2.4
33	Identify the E-waste: characteristics and its management	CO 5	T1: 5.5 R1:5.4
34	Explain the Global environmental problems: climate change and impact on human	CO 5	T1: 5.6 R1:5.5

35	Recognize the Ozone depletion and consequences	CO 5	T1: 5.10 R1:5.6
36	Summarize the International protocols	CO 5	T1: 4.1 R1:1.16
37	Relate the Environmental protection act.	CO 6	T1:7.3
38	Relate the air act, water act	CO 6	T1:7.3
39	Relate forest act, wild life act	CO 6	T1:7.3
40	Relate the Hazardous waste management and handling rules 2016	CO 6	T1:7.10
41	Illustrate the EIA structure and concept of sustainable development	CO 6	T1: 8.1
42	Identify towards sustainable features: concepts of sustainable development	CO 6	T1: 8.2
43	Relate the Consequences of population and its explosion	CO 6	T2: 8.2.3 T3:2
44	Explain the Crazy consumerism urban sprawl	CO 6	T2:8.2.3, T3:7
45	Explain the Environmental education	CO 6	T2:8.4, T3:7
46	Explain the Environmental ethics and concepts of green buildings	CO 6	T2:8.12, T3:15,21
PROBLEM SOLVING			
1	Food chain and pyramids	CO 1	T1:3.3.1; R3:3.2
2	Probelms on utilization of water	CO 1	T2:16.5; R3:8.10
3	Biodiversity	CO 2	T2:16.5; R3:8.10
4	kyto protocol	CO 3	T1:3.3.1; R3:3.2
5	Deforestation	CO 3	T2:16.5; R3:8.10
6	population	CO 4	T2:16.5; R3:8.10
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Environment and Ecosystems	CO 1	T2:16.5; R3:8.10
2	Natural Resources	CO 2	T1:3.3.1; R3:3.2
3	Biodiversity and Biotic Resouces	CO 3	T2:16.5; R3:8.10
4	Enivironment pollution	CO 4	T2:16.5; R3:8.10
5	Environmental Legistration and sustainable development	CO 6	T2:16.5; R3:8.10

DISCUSSION OF QUESTION BANK			
1	Environment and Ecosystems	CO 1	T2:16.5; R3:8.10
2	Natural Resources	CO 2	T1:3.3.1; R3:3.2
3	Biodiversity and Biotic Resouces	CO 3	T2:16.5; R3:8.10
4	Enivironment pollution	CO 4	T2:16.5; R3:8.10
5	Environmental Legistration and sustainable development	CO 6	T2:16.5; R3:8.10

Signature of Course Coordinator **HOD,AERO**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**COMPUTER SCIENCE AND ENGINEERING**				
Course Title	**DATA STRUCTURES**				
Course Code	ACS002				
Program	B.Tech				
Semester	II				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	3	1.5
Course Coordinator	Dr V.Sitharamulu, Associate Professor				

I COURSE OVERVIEW:

The course covers some of the general-purpose data structures and algorithms, and software development. Topics covered include managing complexity, analysis, static data structures, dynamic data structures and hashing mechanisms. The main objective of the course is to teach the students how to select and design data structures and algorithms that are appropriate for problems that they might encounter in real life. This course reaches to student by power point presentations, lecture notes, and lab which involve the problem solving in mathematical and engineering areas.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	ACS001	I	Computer Programming

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Data Structures	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
✓	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into five units and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
20	Remember
40	Understand
25	Apply
15	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc.

VI COURSE OBJECTIVES:

The students will try to learn:

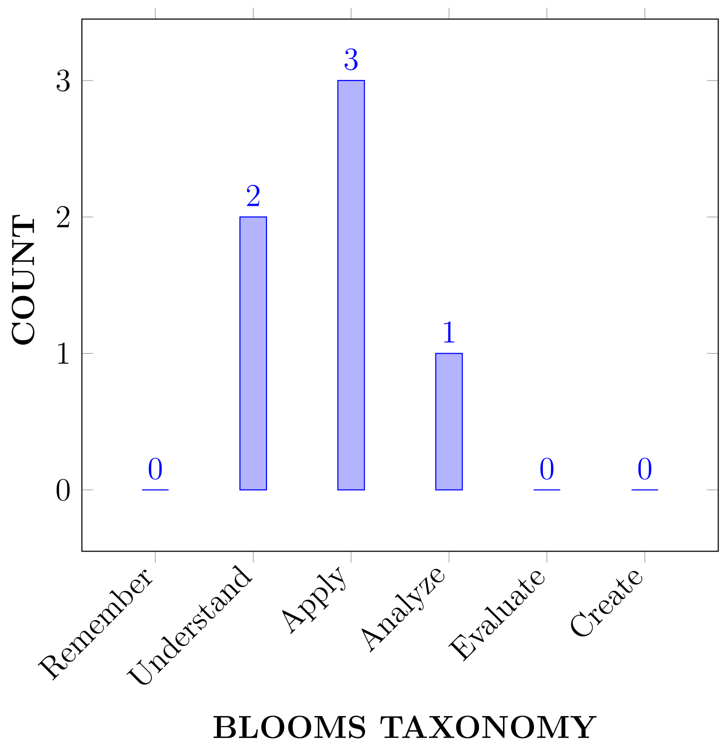
I	The skills needed to understand and analyze performance trade-offs of different algorithms implementations and asymptotic analysis of their running time and memory usage.
II	The knowledge of basic abstract data types (ADT) and associated algorithms: stacks, queues, lists, tree, graphs, hashing and sorting, selection and searching.
III	The fundamentals of Non-linear Data structure to store, retrieve, and process data efficiently.
IV	The implementing these data structures and algorithms and Understand essential for future programming and software engineering courses.
V	Analyze and choose appropriate data structure to solve problems in real world.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Interpret** the complexity of algorithm using the asymptotic notations.	Understand
CO 2	**Select** appropriate searching and sorting technique for a given problem.	Apply
CO 3	**Construct** programs on performing operations on linear and nonlinear data structures for organization of a data	Apply
CO 4	**Make use of** linear data structures and nonlinear data structures solving real time applications.	Apply
CO 5	**Describe** hashing techniques and collision resolution methods for efficiently accessing data with respect to performance.	Understand
CO 6	**Compare** various types of data structures ; in terms of implementation, operations and performance.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

Program Outcomes	
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	CIA/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIA/SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	CIA/SEE
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	CIA/SEE

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	CIA/SEE/Open ended Experiments
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	Tech Talk/Concept Videos/Open ended Experiments
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	1	Tech Talk/Concept Videos/Open ended Experiments

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	**Understand** design and analyze computer programs in the areas related to Algorithms, System Software, Web design, Big data, Artificial Intelligence, Machine Learning and Networking.	3	CIA/ SEE/ Tech Talk/ Concept Videos
PSO 2	**Focus on** improving software reliability, network security information retrieval systems.	2	CIA/ SEE/ Tech Talk/ Concept Videos
PSO 3	**Make use of** modern computer tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2	CIA/ SEE/ Tech Talk/ Concept Videos

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	✓	-	-	-	-	-	-	✓	-	-	✓	-	✓
CO 2	✓	✓	✓	-	✓	-	-	-	-	✓	-	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓	-	-	-	-	✓	-	✓	✓	✓	✓
CO 4	✓	✓	✓	✓	✓	-	-	-	-	✓	-	✓	✓	✓	✓
CO 5	✓	-	✓	-	✓	-	-	-	-	✓	-	-	✓	✓	✓
CO 6	✓	✓	✓	✓	✓	-	-	-	-	✓	-	✓	✓	✓	✓

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO1	PO 1	**Understand** (knowledge) the concept of conventional digital communication system and (understand) various types of pulse analog modulation techniques for signals analysis by applying the principles of **mathematics, science,** and **engineering fundamentals**.	3
	PO 2	**Problem Analysis** on different types of algorithms to analyze space and time complexities.	4

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 3	**Design the Solutions** for finding space and time complexities of a complex algorithm and representing it by asymptotic notations	2
	PO 10	**Subject matter and speaking style** assessed in explanation of various algorithms, algorithm complexity.	2
	PSO1	**Design and analyze** complex algorithms and specify its space and time complexities and representing it by asymptotic notations for faster processing of data.	3
	PSO3	**Make use of modern** computer tools for finding space and time complexities of a complex algorithm	1
CO 2	PO 1	**Make use** of broad knowledge of searching and sorting techniques for an efficient search from a data structure and optimize the efficiency of other algorithms by applying the knowledge of mathematics, science, Engineering fundamentals.	1
	PO 2	**Problem Analysis** on different types of search sort algorithms to analyze space and time complexities.	5
	PO 3	**Design/Development of Solutions** using appropriate searching and sorting techniques for designing a solution for complex Engineering problems.	2
	PO 5	**Implementation of**different sorting and searching techniques for given problem with the help of computer software	1
	PO 10	**Subject matter and speaking style** assessed in explanation of searching and sorting along with efficiency of searching and sorting techniques in terms of space and time complexity	2
	PO 12	**Keeping current in CSE and advanced engineering concepts** of various searching , sorting and respective time and space complexity by tech talk, concept videos and open ended experiments.	3
	PSO1	**Understand**complex problems and analyzing it and apply appropriate sorting and searching techniques for data processing.	4
	PSO2	**Applying**various selecting and sorting techniques while designing and developing information retrieval systems and its applications	2
	PSO3	**Make use of** various selecting and sorting techniques and extend the knowledge for advance frame works and platforms which are necessary for engineering practices and higher studies or become an entrepreneur.	1
CO 3	PO 1	**Make use of** linear and nonlinear data structures to organize the data in a particular way so to use them in the most effective way by applying the basic knowledge of mathematics, science, engineering fundamentals	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	**Problem analysis:** Organizing the given data in particular way by performing the operations on linear and nonlinear data structures to use the data in the most effective way.	7
	PO 3	**Recognize the** need of linear and nonlinear data structures such as linked list, array, stack and queue by Designing solutions for complex Engineering.	5
	PO 4	**Conduct Investigations** Conduct Investigations of Complex Problems: Ability to apply operations on linear and nonlinear data structures in order to organize the given data in a particular way	4
	PO 5	**Implementation of** Implementation of different operations on linear and nonlinear data structures for given problem with the help of computer software	1
	PO 10	**Subject matter and speaking style** assessed in explanation of linear and nonlinear data structures like linked lists, stacks and queues	2
	PO 12	**Keeping current in** CSE and advanced engineering concepts of linear and nonlinear data structures like linked lists, stacks and queues by tech talk, concept videos and open-ended experiments	3
	PSO1	**Understand** complex problems and analyzing it and apply appropriate operations on linear or nonlinear data structures for Developing the solution.	5
	PSO2	**Applying** various linear or nonlinear data structures while designing and developing information retrieval systems and its applications	2
	PSO3	**Make use of** various linear or nonlinear data structures and extend the knowledge for advance frame works and platforms which are necessary for engineering practices and higher studies or become an entrepreneur.	1
CO 4	PO 1	**Make use of** linear and nonlinear data structures for solving real time applications by applying the basic knowledge of mathematics, science, engineering fundamentals	3
	PO 2	**Problem analysis:**Solving real time applications by performing the operations on linear or nonlinear data structures.	7
	PO 3	**Recognize the** need of linear and nonlinear data structures such as linked list, array, stack and queue for Designing real time applications.	2
	PO 4	**Conduct Investigations of Complex Problems:** Ability to apply operations on linear or nonlinear data structures in order to solve real time applications.	4

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 5	**Implementation of** different operations on linear and nonlinear data structures for solving real time applications with the help of computer software	1
	PO 10	**Subject matter and speaking style** assessed in explanation of linear and nonlinear data structures like linked lists, stacks, queues, trees and graphs	2
	PO 12	**Keeping current** in CSE and advanced engineering concepts of linear and nonlinear data structures like linked lists, stacks, queues, trees and graphs by tech talk, concept videos and open-ended experiments for solving real time applications.	3
	PSO1	**Understand** complex problems and analyzing it and apply appropriate operations on linear or nonlinear data structures for solving real time applications.	5
	PSO2	**Applying** various linear or nonlinear data structures while designing and developing information retrieval systems and its applications	1
	PSO3	**Make use of** various linear or nonlinear data structures and extend the knowledge for advance frame works and platforms which are necessary for engineering practices and higher studies or become an entrepreneur.	1
CO 5	PO 1	**Understand** the knowledge of hashing techniques and collision resolution methods and implementing for specified problem domain using knowledge of mathematics, science and engineering fundamentals	1
	PO 3	**Design the Solution** for efficiently accessing data with respect to performance by using hashing techniques and collision resolution methods	2
	PO 5	**Implementation of** hashing techniques and collision resolution methods for efficiently accessing data with respect to performance with the help of computer software	1
	PO 10	**Subject matter and speaking style** assessed in explanation of Hashing, Collision techniques	2
	PSO1	**Understand** complex problems and analyzing it and apply appropriate hashing techniques and collision resolution methods for efficiently accessing data with respect to performance.	4
	PSO2	**Applying** various hashing techniques and collision resolution methods while designing and developing information retrieval systems and its applications	1
	PSO3	**Build** sufficient knowledge hashing techniques and collision resolution methods so that new product can be developed, which leads to become successful entrepreneur in the present market.	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	PO 1	**Understand** various types of data structures in terms of implementations and choose appropriate data structure for specified problem domain using knowledge of mathematics, science and engineering fundamentals	3
	PO 2	**Problem Analysis:** Recognize the importance of suitable data structures in checking the efficiency of algorithms used for complex engineering problems.	7
	PO 3	**Design the Solution** complex problems or efficiently accessing data with respect to performance by using hashing techniques and collision resolution methods	5
	PO 4	**Conduct Investigations of Complex Problems:** Ability to apply operations on linear or nonlinear data structures in order to solve real time applications.	4
	PO 5	**Understand** the Implementation of various types of data structures with the help of computer software	1
	PO 10	**Subject matter and speaking** style assessed in explanation of Implementation of various types of data structures.	2
	PO 12	**Keeping current in CSE** and advanced engineering concepts of Implementation of various types of data structures by tech talk, concept videos and open ended experiments	3
	PSO 1	**Understand** complex problems and analyzing it and apply Implementation of various types of data structures.	5
	PSO 2	**Applying** Implementation of various types of data structures while designing and developing information retrieval systems and its applications	1
	PSO 3	**Build** sufficient knowledge Implementation of various types of data structures so that new product can be developed, which leads to become successful entrepreneur in the present market.	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	10	10	11	1	5	3	3	12	5	12	12	6	2	2
CO 1	1	4	2	-	-	-	-	-	-	2	-	-	3	-	1
CO 2	1	5	2	-	1	-	-	-	-	2	-	3	4	2	1
CO 3	2	7	5	4	1	-	-	-	-	2	-	3	5	2	1
CO 4	3	7	2	4	1	-	-	-	-	2	-	3	5	1	1
CO 5	1	-	2	-	1	-	-	-	-	2	-	-	4	1	1
CO 6	3	7	5	4	1	-	-	-	-	2	-	3	5	1	1

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	10	10	11	1	5	3	3	12	5	12	12	2	2	2
CO 1	33.3	40	20	-	-	-	-	-	-	40	-	-	50	-	50
CO 2	33.3	50	20	-	100	-	-	-	-	40	-	25	66.6	100	50
CO 3	66.6	70	50	36.3	100	-	-	-	-	40	-	25	83.3	100	50
CO 4	100	70	20	36.3	100	-	-	-	-	40	-	-	66.6	50	50
CO 5	33.3	-	20	-	100	-	-	-	-	40	-	-	66.6	50	50
CO 6	100	70	50	36.3	100	-	-	-	-	40	-	25	83.3	50	50

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, **0** being **no correlation**, **1** being the **low correlation**, **2** being **medium correlation** and **3** being **high correlation**.

0 - $0 \leq C \leq 5\%$ – No correlation
1 - $5 < C \leq 40\%$ – Low/ Slight
2 - $40\% < C < 60\%$ – Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	**PROGRAM OUTCOMES**												**PSO'S**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	1	1	-	-	-	-	-	-	1	-	-	2	-	2
CO 2	1	2	1	-	3	-	-	-	-	1	-	1	3	3	2
CO 3	3	3	2	1	3	-	-	-	-	1	-	1	3	3	2
CO 4	3	3	1	1	3	-	-	-	-	1	-	1	3	2	2
CO 5	1	-	1	-	3	-	-	-	-	1	-	-	3	2	2
CO 6	3	3	2	1	3	-	-	-	-	1	-	1	3	2	2
TOTAL	**12**	**12**	**8**	**3**	**15**	**-**	**-**	**-**	**-**	**6**	**-**	**4**	**17**	**12**	**12**
AVERAGE	**2.0**	**2.4**	**1.3**	**1.0**	**3.0**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2.8**	**2.4**	**2.0**

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Seminars	-	Student Viva	-	Certification	-
Laboratory Practices	-	5 Minutes Video	-	Open Ended Experiments	-
Term Paper	-	-	-	-	-

XVII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO DATA STRUCTURES, SEARCHING AND SORTING**
	Basic concepts: Introduction to data structures, classification of data structures, operations on data structures; Algorithms Specification ,Recursive algorithms ,Data Abstraction, Performance analysis-time complexity and space complexity, Asymptotic Notation-Big O ,Omega and Theta notations. Introduction to Linear and Non Linear data structures, Searching techniques: Linear search, Binary search; Sorting techniques: Bubble, Selection, Insertion, Quick and Merge Sort and comparison of sorting algorithms
MODULE II	**LINEAR DATA STRUCTURES**
	Stacks: Primitive operations, implementation of stacks using Arrays, applications of stacks arithmetic expression conversion and evaluation; Queues: Primitive operations; Implementation of queues using Array, applications of linear queue, circular queue and double ended queue (deque).
MODULE III	**LINKED LISTS**
	Linked lists: Introduction, singly linked list, representation of a linked list in memory, operations on a single linked list; Applications of linked lists: Polynomial representation and sparse matrix manipulation. Types of linked lists: Circular linked lists, doubly linked lists; Linked list representation and operations of Stack, linked list representation and operations of queue
MODULE IV	**NON LINEAR DATA STRUCTURES**
	Trees: Basic concept, binary tree, binary tree representation, array and linked representations, binary tree traversal, binary search tree, tree variants, application of trees; Graphs: Basic concept, graph terminology, graph implementation, graph traversals, Application of graphs, Priority Queue.
MODULE V	**BINARY TREES AND HASHING**
	Binary search trees: Binary search trees, properties and operations; Balanced search trees: AVL trees; Introduction to M-Way search trees, B trees; Hashing and collision: Introduction, hash tables, hash functions, collisions, applications of hashing.

TEXTBOOKS

1. Mark A. Weiss, —Data Structures and Algorithm Analysis in C, Pearson, 2nd Edition, 1996.
2. Ellis Horowitz, Satraj Sahni, Susan Anderson Freed, —Fundamentals of Data Structures in C‖, Universities Press, 2nd Edition, 2008.

REFERENCE BOOKS:

1. Reema Thareja, —Data Structures using C, Oxford University Press, 2nd Edition, 2014
2. S. Lipschutz, —Data Structures‖, Tata McGraw Hill Education, 1st Edition, 2008.
3. D. Samanta, —Classic Data Structures‖, PHI Learning, 2nd Edition, 2004.
4. Tanenbaum, Langsam, Augenstein, —Data Structures Using C‖, Pearson, 1st Edition, 2003.

WEB REFERENCES:

1. http://www.tutorialspoint.com/data-structures-algorithms
2. https://www.geeksforgeeks.org/data-structures/
3. https://www.studytonight.com/data-structures/
4. https://www.coursera.org/specializations/data-structures-algorithms

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=courses/computer-science-and-engineering-autonomous/datastructures

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	https://lms.iare.ac.in/index?route=course/details&course_id=188
CONTENT DELIVERY (THEORY)			
1	Basic concepts: Introduction to Data Structures	CO 3	T1:1.1.3 R2 : 1.2
2	Classification of data structures	CO 3	T1:1.1.3 R2 : 1.4
3	Operations on data Structures	CO 3	T1:1.2
4	Recursive algorithm, Performance Analysis	CO1	T1:1.2 T1:5.1
5	Searching techniques: Linear search and binary search	CO 2, CO 6	T1:5.1

6	Searching techniques: Fibonacci search and companding	CO 2, CO 6	T1:5.1
8	Sorting techniques: Bubble sort, selection sort and companding	CO 2	R1:14.5
9	Sorting techniques: Insertion sort, Quick sort	CO 2,	T1:5.2 R2 : 10.2
10	Merge sort ,comparison of sorting algorithms	CO 2, CO 6	T1:5.2 R2 : 10.2
13	Stacks: Primitive operations, implementation of stacks using Arrays	CO3,	T1:7.1
14	Applications of stacks arithmetic expression conversion and evaluation	CO 3, CO 4	T1:7.2
16	Queues: Primitive operations; Implementation of queues using Array	CO 3,	T1:8.1
17	Applications of linear queue, circular queue	CO 3, CO 4	T1:8.4
18	Double ended queue (deque)l	CO 3	R2 : 5.4
19	Linked lists: Introduction, singly linked list, representation of a linked list in memory	CO 3,	T1:9.1
20	Operations on a single linked list :creation, insertion and deletion	CO3,	T1:9.2
21	Applications of linked lists	CO 3, CO 4	T1:9.3
22	Operations on a double linked lists :creation, insertion and deletion	CO 3,	T1:9.4
23	Operations on a double linked lists : deletion ,traversal.	CO 3,	T1:9.4
24	single linked list :polynomial expression	CO 3	T1:9.3
25	single linked list :Sparse matrix manipulation.	CO3,	T1:9.3
26	Operations on a Circular linked lists: creation, insertion and deletion	CO 3,	T1:9
30	Operations on a Circular linked lists: deletion, traversal	CO3, CO 4	T1:9
31	Linked list representation and operations of Stack	CO3,	T1:9.7
32	Linked list representation and operations of queue	CO 4,	T1:9.8
37	Trees: Basic concept, Tree terminology	CO 3,	T1:13.1

CONTENT DELIVERY (THEORY)			
38	Binary tree :Binary Tree properties	CO 3,	T1:13.1
39	Binary tree representation using array	CO 3,	T1:13.2
40	Binary tree representation using linked list	CO 4,	T1:13.2
41	Binary tree traversal, binary tree variants	CO4,	T1:13.2
42	Application of trees	CO 4	T1:13.2.3
44	Graphs: Basic concept, graph terminology	CO 3	R2 : 8.2
45	Types of graphs, Representation of graph	CO 3	R2 : 8.2
46	Graph traversals :DFS and BFS, Application of graphs	CO 4	T2:6.2
48	Minimum Spanning Trees-Prims and Kruskal algorithms	CO 4	T1:6.1 T2:5.6
50	Binary search trees, properties	CO 3	T1:13.2.3
51	Binary search trees operations	CO 4	T1:13.2.3
52	AVL trees	CO 3	T1:14.3
53	M- Way search trees, B trees	CO 4	T1:14.3
54	Hashing, Collision	CO 5	R2 : 6.4
7	Problems on linear search, binary search and Fibonacci search.	CO 4	T1:5.1
11	Problems on bubble sort, selection and insertion sort	CO 4, CO 6	T1:5.2 R2 : 10.2
12	Problems on quick and merge sort	CO 4, CO 6	T1:5.2 R2 : 10.2
15	Problems on Arithmetic expression conversion and evaluation	CO 4,	T1:7.2
27	Problems on single linked list to add, delete element	CO 4,	T1:9.8
28	Problems on double linked list to add, delete element	CO 4,	T1:9.8
33	Problems on circular linked list to add, delete element	CO 4,	T1:9.4
34	Problems on double linked list to add, delete element	CO 4,	T1:9.3
35	Problems on stack using linked list	CO 4,	T1:9.7
36	Problems on queue using linked list	CO 4,	T1:9.8
43	Problems on Binary tree :creation ,insertion and deletion of a node	CO 4,	T1:13.2
47	Problems on Graph Traversal: DFS and BFS	CO 4,	T2:6.2

49	Problems on MST: Prim's and Kruskal's	CO 4,	T1:6.1 T2:5.6
55	Problems on Binary search tree	CO 4	T1:14.3
56	Problems oh hashing	CO 5	R2 : 6.4
DISCUSSION ON DEFINITION AND TERMINOLOGY			
57	Definitions on Data Structures, searching and sorting	CO2	T1:1 R1:14
58	Definitions on Linear Data Structures	CO 3	T1:7,.T1:8
59	Definitions on Linked Lists	CO 3	T1:9
60	Definitions on Non Linear data Structures	CO 3	T1:7.5
61	Definitions on Binary Trees and Hashing	CO 3,CO 5	T1:14
DISCUSSION ON QUESTION BANK			
62	Module I	CO 1, CO2,CO6	T1:1 R1:14
63	Module I I	CO 3,CO 4,CO 6	T1:9
64	Module III	CO 3,CO 4,CO 6	T1:2.5
65	Module IV	CO 3,CO 4,CO 6	T1: 4.1
66	Module V	CO 3,CO 5,CO 6	T1: 5.1

Course Coordinator **HOD,CSE**
Dr V.Sitharamulu

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**ENGLISH LANGUAGE AND COMMUNICATION SKILLS LABORATARY**				
Course Code	AHS101				
Program	B.Tech				
Semester	I	EEE			
Course Type	Foundation				
Regulation	R 16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Dr. Jetty Wilson, Professor				

I COURSE OVERVIEW:

This lab course is designed to introduce the students to create wide exposure on language learning techniques regarding the basic elements of Listening, Speaking, Reading and Writing. In this lab the students are trained in communicative English language skills, phonetics, word accent, word stress, rhythm and intonation, oral presentations, extempore and Prepared-seminars, group-discussions, pre-sending techniques of writing, participating role plays, telephonic etiquettes, asking and giving direction, information transfer , debates, description of persons, places, objects etc.; . The lab encourages the students to work in a group, engage in peer-reviews and inculcate team spirit through various exercises on grammar, vocabulary, and pronunciation games etc. Students will make use of all these language skills in academic, professional and real time situations.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
10+2	-	-	Basic principles of communication skills and concepts of functional English grammar.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
English Language and CommunicationSkills Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the Principal from the panel of experts recommended by Chairman, BOS. The emphases on the experiments is broadly based on the following criteria given in Table: 1

	Software based
20 %	To test the perfection of primary tonic stress accent, pre-tonic secondary stress accent and post-tonic secondary stress accent.
20 %	To test the performance to achieve neutralization of accent.
20 %	To test the awareness while pronouncing germination, elision and assimilation.
20 %	To test the presentation skills in the ICS laboratory.
20 %	To test the subject knowledge through viva.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Software based**

Objective	Analysis	Design	Conclusion	Viva	Total
4	4	4	4	4	20

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
-	-	-	-	-	-

VI COURSE OBJECTIVES:

The students will try to learn:

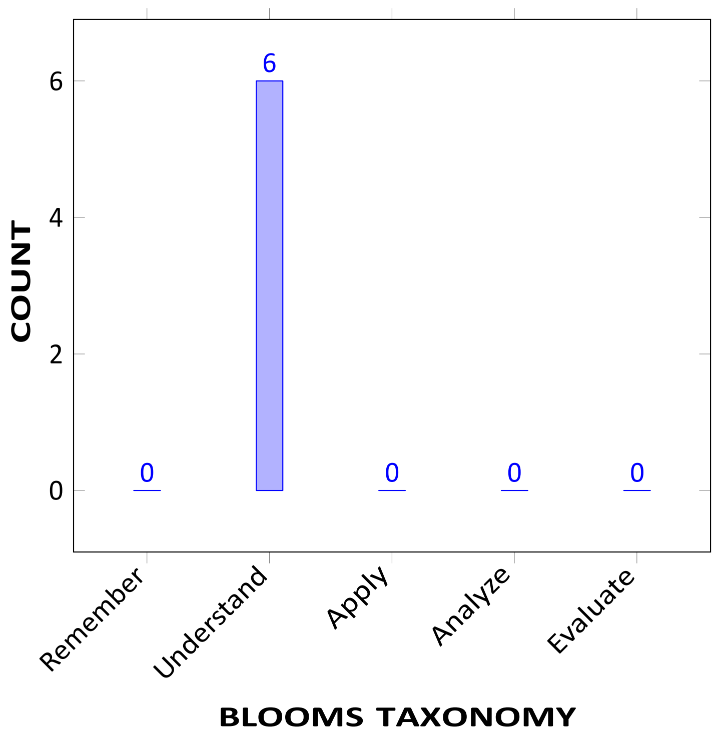
I	Facilitate computer-assisted multi-media instructions to make possible individualized and independent language learning.
II	The critical aspect of speaking and reading for interpreting in-depth meaning of the sentences.
III	Use language appropriately for social interactions such as public speaking, group discussions and interviews.
IV	Habituate using English speech sounds, word accent, intonation and rhythm.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Discuss** the prime necessities of listening skill for improving pronunciation in academic and non-academic purposes.	Understand
CO 2	**Summarize** the knowledge of English phonetics for speaking accepted language and describe the procedure of phonemic transcriptions and intonation patterns.	Understand
CO 3	**Express** about necessity of stressed and unstressed syllables in a word with appropriate length and clarity.	Understand
CO 4	**Explain** how writing skill fulfill the academic and non-academic requirements of various written communicative functions.	Understand
CO 5	**Generalize** appropriate concepts and methods from a variety of disciplines to solve problems effectively and creatively.	Understand
CO 6	**Classify** the roles of collaboration, risk-taking, multi-disciplinary awareness, and the imagination in achieving creative responses to problems.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	Day-to-day evaluation / CIE/SEE
PO 10	**Communicate:** effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (Communication).	5	Day-to-day evaluation / CIE/SEE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Design next-generation computer systems, networking devices, search engines, soft computing and intelligent systems, web browsers, and knowledge discovery tools.	-	-
PSO 2	Focus on mobile and web applications development and learn the emerging technologies and frameworks in demand with employers and contemporary challenges.	-	-
PSO 3	Practical experience in shipping real world software, using industry standard tools and collaboration techniques will equip to secure and succeed in first job upon graduation in IT industry.	-	-

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 10	Discuss the heeds of functional **grammar** and **punctuation** tools in **speaking** and **writing** by generating the **clarity** of an audio text.	5
CO 2	PO 9	Define the meaning of **individual work** and **team work** and also participate effectively to develop **leadership** qualities among the **diverse teams** in **multidisciplinary** settings.	5
CO 3	PO 10	Describe the **clarity** of **grammatical** usage and the obligation of **punctuation** marks in **speaking** and **writing**.	5
CO 4	PO 10	Choose suitable **grammatical** structures and **punctuation** marks at **speaking** and **writing** areas maintaining **clarity** at professional platform.	5

CO 5	PO 10	Interpret the **grammatical** knowledge and **punctuation** marks systematically towards providing the **clarity** in **speaking** and **writing**.	5
CO 6	PO 10	Demonstrate the role of grammar **and** punctuation marks understanding the meaning between the sentences aswell as paragraphs in **speaking** or **writing** for a **clarity**.	5

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES			PSO'S
	PO 9	PO 10	-	PSO
CO 1	-	5	-	-
CO 2	3	-	-	-
CO 3	-	5	-	-
CO 4	-	5	-	-
CO 5	-	5	-	-
CO 6	-	5	-	

XII ASSESSMENT METHODOLOGY DIRECT:

Laboratory Practices	PO 9, PO 10	Student Viva	PO 9, PO 10	Certification	-
Assignments	-	-	-	-	

XIII ASSESSMENT METHODOLOGY INDIRECT:

√	Early Semester Feedback	√	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**INTRODUCTION ABOUT ELCS LAB..**
	Introducing Self and Introducing Others – feedback.
WEEK II	**INTRODUCTION TO PHONETICS AND PRACTICING CONSONANTS**
	Describing a person or place or a thing using relevant adjectives – feedback.
WEEK III	**PRACTICING VOWEL SOUNDS.**
	JAM Sessions using public address system.
WEEK IV	**STRUCTURE OF SYLLABLES.**
	Giving directions with help of using appropriate phrases – activities.
WEEK V	**WORD ACCENT AND STRESS SHIFTS. – PRACTICE EXERCISES.**
	Starting a conversation, developing and closing appropriately using fixed expressions..
WEEK VI	**PAST TENSE AND PLURAL MARKERS.**
	Role Play activities.

WEEK VII	**WEAK FORMS AND STRONG FORMS.**
	Oral Presentation...
WEEK VIII	**INTRODUCTION TO INTONATION- USES OF INTONATION - TYPES OF INTONATION- PRACTICE EXERCISES.**
	Expressions In Various Situations.
WEEK IX	**NEUTRALIZATION OF MOTHER TONGUE INFLUENCE (MTI).**
	Sharing Summaries Or Reviews On The Topics Of Students' Choice.
WEEK X	**COMMON ERRORS IN PRONUNCIATION AND PRONUNCIATION PRACTICE THROUGH TONGUE TWISTERS.**
	Interpretation Of Proverbs And Idioms.
WEEK XI	**LISENING COMPREHENSION.**
	Etiquettes.
WEEK XII	**TECHNIQUES AND METHODS TO WRITE SUMMARIES AND REVIEWS OF VIDEOS.**
	Writing Messages, Leaflets And Notices Etc.
WEEK XIII	**COMMON ERRORS.**
	Resume Writing.
WEEK XIV	**INTRODUCTION TO WORD DICTIONARY.**
	Group Discussions – Video Recording – Feedback.
WEEK XV	**INTRODUCTION TO CONVERSATION SKILLS.**
	Mock Interviews.

TEXTBOOKS

1. ENGLISH LANGUAGE AND COMMUNICATION SKILLS: LAB MANUAL

REFERENCE BOOKS:

1. . Meenakshi Raman, Sangeetha Sharma, "Technical Communication Principles and Practices", Oxford University Press, New Delhi, 3rd Edition, 2015.
2. Rhirdion, Daniel, "Technical Communication", Cengage Learning, New Delhi, 1st Edition, 2009.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Introduction About Elcs Lab, Introducing Self And Introducing Others – Feedback.	CO 2	R1: 1.2
2	Introduction To Phonetics And Practicing Consonants, Describing A Person Or Place Or A Thing Using Relevant Adjectives – Feedback.	CO 2	R2: 25-30
3	Practicing Vowel Sounds, Jam Sessions Using PublicAddress System.	CO 2	R1: 28-29,49-54
4	Structure Of Syllables, Giving Directions With Help Of Using Appropriate Phrases – Activities.	CO 3	R1: 23-38

5	Word Accent And Stress Shifts. – Practice Exercises, Starting A Conversation, Developing And Closing Appropriately Using Fixed Expressions.	CO 3	R1: 2.4
6	Past Tense And Plural Markers,	CO 2	R3: 4.5
7	Weak Forms And Strong Forms, Oral Presentation.	CO 2	R3: 4.6
8	Introduction To Intonation- Uses Of Intonation - Types Of Intonation- Practice Exercises, expressions In Various Situations.	CO 2	R2: 39-42
9	Neutralization Of Mother Tongue Influence (MT), Sharing Summaries Or Reviews On The Topics Of Students' Choice.	CO 2	R2: 5.2
10	Common Errors In Pronunciation And Pronunciation Practice Through Tongue Twisters, Interpretation Of Proverbs And Idioms.	CO 2	R1:42-43
11	Listening Comprehension, Etiquettes	CO 5	R1:44-48
12	Techniques And Methods To Write Summaries And Reviews Of Videos, Writing Messages, Leaflets And Notices Etc.	CO 4	R1:107-110
13	Common Errors, Resume Writing.	CO 4	R1:7.3
14	Introduction To Word Dictionary, Group Discussions –Video Recording – Feedback.	CO 5	R1:7.3
15	Introduction To Conversation Skills, Mock Interviews.	CO 6	R1: 54-58

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments.
1	**Effective listening skills can be used in professional and personal platforms in future.**
2	**By learning LSRW skills, students can enhance desired language skills to fulfill their needs.**
3	**Practicing presentation skills will boost confidence at work place.**
4	**The overall experiments of the laboratory will lead to be an effective communicator.**
5	**The Students will develop critical comprehensive skills to solve the career related problems in future.**

Signature of Course Coordinator **HOD**
Dr. Jetty Wilson, Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

INFORMATION TECHNOLOGY

COURSE DESCRIPTION

Course Title	**DATA STRUCTURES LABORATORY**					
Course Code	ACS102					
Program	B.Tech					
Semester	II	IT				
Course Type	Core					
Regulation	IARE - R16					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	-	-	-	3	2	
Course Coordinator	Ms.B Rekha, Assistant Professor,IT					

I COURSE OVERVIEW:

A data structure is a particular way of organizing data in a computer so that it can be used effectively. It covers the design and analysis of fundamental data structures and engages learners to use data structures as tools to algorithmically design efficient computer programs that will cope with the complexity of actual applications. A Data Structure is a particular way of storing and organizing data in a computer so that it can be stored, retrieved, or updated efficiently. Data structures are generally based on the ability of a computer to fetch and store data at any place in its memory, specified by an address. This course is essential for image viewer software, in this images are linked with each other so, images uses a linked list to view the previous and the next images using the previous and next buttons. Web pages can be accessed using the previous and the next URL links which are linked using linked list. The music players also use the same technique to switch between music. To keep the track of turns in a multi player game, a circular linked list is used.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	ACS002	II	Data Structures
B.Tech	ACS101	I	Computer Programming Laboratory

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Data Structures Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

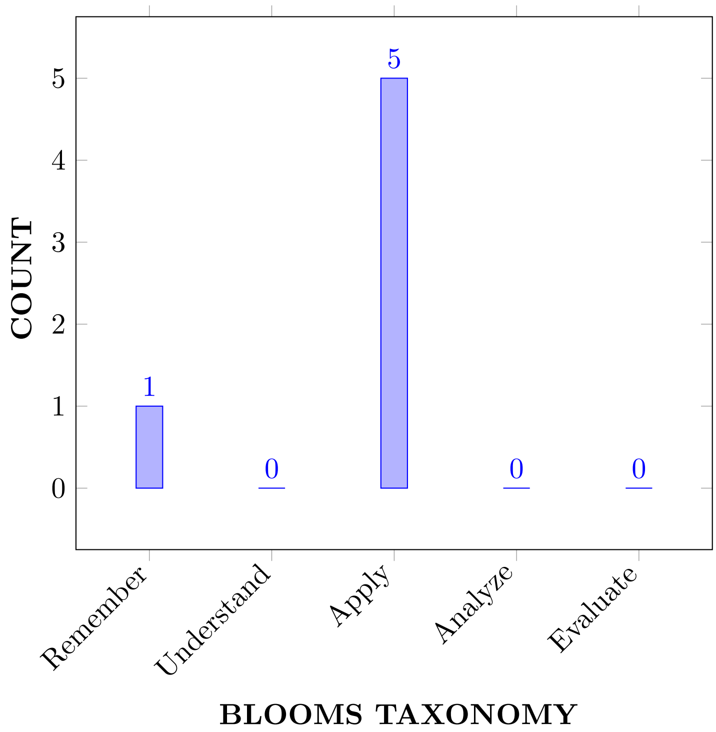
I	Implement linear and non linear data structures.
II	Analyze various algorithms based on their time complexity. .
III	Choose appropriate data structure and algorithm design method for a specific application.
IV	Identify suitable data structure to solve various computing problems.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Identify** appropriate searching technique for efficient retrieval of data stored location. .	Apply
CO 2	**choose** sorting technique to represent data in specified format to to optimize data searching.	Apply
CO 3	**Make use of** stacks and queues representation, operations and their applications to organize specified data	Understand
CO 4	**utilize** linked lists to implement and perform operations for for organizing specified data	Apply
CO 5	**Construct** tree to perform different traversal techniques	Apply
CO 6	**Select** Appropriate graph traversal techniques to visit the vertices of a graph	Remember

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises
PO 2	**Problem Analysis:** Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences	3	Lab Exercises
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	Lab Exercises
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions	2	Lab Exercises
PO 5	**Modern Tool Usage:**Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1	Lab Exercises
PO 6	**The Engineer and Society** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice	2	Lab Exercises
PO 7	**Environment and Sustainability** Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development	2	Lab Exercises
PO 8	**Ethics** Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice	3	Lab Exercises
PO 9	**Individual and Teamwork** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	3	Lab Exercises

PO 10	**Communication:** Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	4	Lab Exercises
PO 12	**Life - Long Learning:**Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Design next-generation computer systems, networking devices, search engines, soft computing and intelligent systems, web browsers, and knowledge discovery tools.	2	Lab Exercises
PSO 2	Focus on mobile and web applications development and learn the emerging technologies and frameworks in demand with employers and contemporary challenges..	2	Lab Exercises
PSO 3	Practical experience in shipping real world software, using industry standard tools and collaboration techniques will equip to secure and succeed in first job upon graduation in IT industry.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	**Justification for mapping (Students will be able to)**	No. of Key Competencies
CO 1	PO 1	Identify appropriate searching technique for efficient retrieval of data stored location by applying the **principles of Mathematics and Engineering** , **Scientific principles and methodology**,**engineering disciplines to integrate / support study**	3
	PO 2	Identify appropriate searching technique for efficient retrieval of data stored location by applying Problem Analysis **Problem statement and system definition**,**Information and data collection**,**Solution development or experimentation / Implementation**	3
	PO 3	**Identify** appropriate searching technique for efficient retrieval of data stored location by applying **Design/Development of Solutions**	3

	PO 4	Identify**apply**appropriate searching technique for efficient retrieval of data stored location by applying **Conduct Investigations of Complex Problems**	2
	PO 5	Identify**apply**appropriate searching technique for efficient retrieval of data stored location by applying Computer software / simulation packages / diagnostic equipment / technical library resources / literature search toolsl	1
	PO 6	Identify**apply**appropriate searching technique for efficient retrieval of data stored location by applying **reasoning informed by the contextual knowledge**	2
	PO 8	Identify**apply**appropriate searching technique for efficient retrieval of data stored location by applying **ethical principles** and commit to professional **ethics and responsibilities** and norms of the Engineering practice	3
	PO 9	Identify**apply**appropriate searching technique for efficient retrieval of data stored location by applying Function **effectively** as an individual, and as a member or leader to get Ability to work with all levels of people in an organization	3
	PO 10	Identify**apply**appropriate searching technique for efficient retrieval of data stored location by **Communicate effectively** on **complex Engineering activities**	3
	PO 12	Identify**apply**appropriate searching technique for efficient retrieval of data stored location by **Keeping current in CSE and advanced engineering concepts**	3
	PSO 1	Identify appropriate searching technique for efficient retrieval of data stored location in **search engines**	2
	PSO 2	Identify appropriate searching technique for efficient retrieval of data stored location in **mobile and web applications development**	2
	PSO 3	Identify appropriate searching technique for efficient retrieval of data stored location **in shipping real world software, using industry standard tools**	3
CO 2	PO 1	choose sorting technique to represent data in specified format to optimize data searching by applying the **principles of Mathematics and Engineering** , **Scientific principles and methodology**,**engineering disciplines to integrate / support study**	3
	PO 2	choose sorting technique to represent data in specified format to optimize data searching by applying Problem Analysis **Problem statement and system definition**,**Information and data collection**,**Solution development or experimentation / Implementation**	3
	PO 3	**Identify** choose sorting technique to represent data in specified format to optimize data searching by applying **Design/Development of Solutions**	3
	PO 4	**choose** sorting technique to represent data in specified format to optimize data searching by applying **Conduct Investigations of Complex Problems**	2

	PO 5	choose sorting technique to represent data in specified format to optimize data searching by applying Computer software / simulation packages / diagnostic equipment / technical library resources / **literature search toolsl**	1
	PO 6	choose sorting technique to **represent** data in specified format to optimize data searching by applying **reasoning informed by the contextual knowledge**	2
	PO 8	**choose** sorting technique to represent data in specified format to optimize data searching by applying **ethical principles** and commit to professional **ethics and responsibilities** and norms of the Engineering practice	3
	PO 9	choose sorting technique to **represent** data in specified format to optimize data searching by applying Function **effectively** as an individual, and as a member or leader to get Ability to work with all levels of people in an organization	3
	PO 10	choose**Apply** sorting technique to represent data in specified format to optimize data searching by **Communicate effectively** on **complex Engineering activities**	3
	PO 12	**choose** sorting technique to **represent** data in specified format to optimize data searching by **Keeping current in CSE and advanced engineering concepts**	3
	PSO 1	choose**Apply** sorting technique to represent data in specified format to optimize data searching in **search engines**	2
	PSO 2	choose**Apply** sorting technique to represent data in specified format to optimize data searching in **mobile and web applications development**	2
	PSO 3	choose**Apply** sorting technique to represent data in specified format to optimize data searching **in shipping real world software, using industry standard tools**	3
CO 3	PO 1	Make use of stacks and queues representation, operations and their applications to organize specified data by applying the **principles of Mathematics and Engineering** , **Scientific principles and methodology**,**engineering disciplines to integrate / support study**	3
	PO 2	Make use of stacks and queues representation, operations and their applications to organize specified data by applying Problem Analysis **Problem statement and system definition**,**Information and data collection**,**Solution development or experimentation / Implementation**	3
	PO 3	**Identify**, **Make use of** stacks and queues representation, operations and their applications to organize specified data by applying **Design/Development of Solutions**	3

	PO 4	Make use of **Apply**stacks and queues representation, operations and their applications to organize specified data by applying **Conduct Investigations of Complex Problems**	2
	PO 5	Make use of stacks and queues representation, operations and their applications to organize specified data by applying Computer software / simulation packages / diagnostic equipment / technical library resources / **literature search tools**	1
	PO 6	**Make use of** stacks and queues representation, operations and their applications to organize specified data by applying **reasoning informed by the contextual knowledge**	2
	PO 8	Make use of stacks and queues **representation**, operations and their applications to organize specified data by applying **ethical principles** and commit to professional **ethics and responsibilities** and norms of the Engineering practice	3
	PO 9	**Make use of** stacks and queues representation, operations and their applications to organize specified data by applying Function **effectively** as an individual, and as a member or leader to get Ability to work with all levels of people in an organization	3
	PO 10	Make use of stacks and queues representation, **operations and their applications** to organize specified data by **Communicate effectively** on **complex Engineering activities**	3
	PO 12	Make use of stacks and queues **representation**, operations and their applications to organize specified data by **Keeping current in CSE and advanced engineering concepts**	3
	PSO 1	Make use of stacks and queues **representation**, operations and their applications to organize specified data in **search engines**	2
	PSO 2	Make use of stacks and queues **representation**, operations and their applications to organize specified data **mobile and web applications development**	2
	PSO 3	Make use of stacks and queues **representation**, operations and their applications to organize specified data **in shipping real world software, using industry standard tools**	2
CO 4	PO 1	utilize linked lists to implement and perform operations for organizing specified data by applying the **principles of Mathematics and Engineering , Scientific principles and methodology**,**engineering disciplines to integrate / support study**	3

	PO 2	utilize linked lists to implement and perform operations for organizing specified data by applying Problem Analysis **Problem statement and system definition**,**Information and data collection**,**Solution development or experimentation / Implementation**	3
	PO 3	utilize**Apply** linked lists to **implement** and perform operations for organizing specified data by applying **Design/Development of Solutions**	3
	PO 4	utilize linked lists to **implement** and perform operations for organizing specified data by applying **Conduct Investigations of Complex Problems**	2
	PO 5	utilize linked lists to implement and perform operations for organizing specified data by applying Computer software / simulation packages / diagnostic equipment / technical library resources / **literature search toolsl**	1
	PO 6	utilize linked lists to implement and perform operations for organizing specified data by applying **reasoning informed by the contextual knowledge**	2
	PO 8	utilize linked lists to **implement** and perform operations for organizing specified data by applying **ethical principles** and commit to professional **ethics and responsibilities** and norms of the Engineering practice	3
	PO 9	utilize **Apply**linked lists to implement and perform operations for organizing specified data by applying Function **effectively** as an individual, and as a member or leader to get Ability to work with all levels of people in an organization	3
	PO 10	utilize linked lists to implement and **perform** operations for organizing specified data by **Communicate effectively** on **complex Engineering activities**	3
	PO 12	utilize**Apply** linked lists to implement and perform operations for organizing specified data by **Keeping current in CSE and advanced engineering concepts**	3
	PSO 1	utilize**Apply** linked lists to implement and perform operations for organizing specified in **search engines**	2
	PSO 2	utilize**Apply** linked lists to implement and perform operations for organizing specified in **mobile and web applications development**	2
	PSO 3	utilize**Apply** linked lists to implement and perform operations for organizing specified **in shipping real world software, using industry standard tools**	2
CO 5	PO 1	Construct tree to perform different traversal techniques by applying the **principles of Mathematics and Engineering** , **Scientific principles and methodology**,**engineering disciplines to integrate / support study**	3

	PO 2	Construct tree to perform different traversal techniques by applying Problem Analysis **Problem statement and system definition**,**Information and data collection**,**Solution development or experimentation / Implementation**	3
	PO 3	Construct**Apply** tree to **perform** different traversal techniques by applying **Design/Development of Solutions**	3
	PO 4	**Construct** tree to perform different traversal techniques by applying **Conduct Investigations of Complex Problems**	2
	PO 5	Construct tree to perform different traversal techniques by applying Computer software / simulation packages / diagnostic equipment / technical library resources / **literature search tools**	1
	PO 6	Construct tree to **perform** different traversal techniquesby applying **reasoning informed by the contextual knowledge**	2
	PO 8	ConstructApply tree to perform different traversal techniques by applying **ethical principles** and commit to professional **ethics and responsibilities** and norms of the Engineering practice	3
	PO 9	Construct tree to perform different traversal techniquesby applying Function **effectively** as an individual, and as a member or leader to get Ability to work with all levels of **people in an organization**	3
	PO 10	Construct tree to **perform** different traversal techniques by **Communicate effectively** on **complex Engineering activities**	3
	PO 12	**Construct** tree to perform different traversal techniques by **Keeping current in CSE and advanced engineering concepts**	3
	PSO 1	Construct tree to **perform** different traversal techniques in **search engines**	2
	PSO 2	Construct tree to **perform** different traversal techniques in **mobile and web applications development**	2
	PSO 3	Construct tree to **perform** different traversal techniques **in shipping real world software, using industry standard tools**	2
CO 6	PO 1	Select Appropriate graph traversal techniques to visit the vertices of a graph by applying the **principles of Mathematics and Engineering** , **Scientific principles and methodology**,**engineering disciplines to integrate / support study**	3
	PO 2	Select Appropriate graph traversal techniques to visit the vertices of a graph by applying Problem Analysis **Problem statement and system definition**,**Information and data collection**,**Solution development or experimentation / Implementation**	3

	PO 3	Select Appropriate graph traversal techniques to visit the vertices of a graph by applying **Design/Development of Solutions**	3
	PO 4	**Select** Appropriate graph traversal techniques to visit the vertices of a graph by applying **Conduct Investigations of Complex Problems**	2
	PO 5	Select Appropriate graph traversal techniques to visit the vertices of a graph by applying Computer software / simulation packages / diagnostic equipment / technical library resources / **literature search tools**	1
	PO 6	**Select** Appropriate graph traversal techniques to visit the vertices of a graph by applying **reasoning informed by the contextual knowledge**	2
	PO 8	**Select** Appropriate graph traversal techniques to visit the vertices of a graph by applying **ethical principles** and commit to professional **ethics and responsibilities** and norms of the Engineering practice	3
	PO 9	**Select** Appropriate graph traversal techniques to visit the vertices of a graph by applying Function **effectively** as an individual, and as a member or leader to get Ability to work with all levels of people in an organization	3
	PO 10	**Select** Appropriate graph traversal techniques to visit the vertices of a graph by **Communicate effectively** on **complex Engineering activities**	3
	PO 12	**Select** Appropriate graph traversal techniques to visit the vertices of a graph by **Keeping current in CSE and advanced engineering concepts**	3
	PSO 1	**Select** Appropriate graph traversal techniques to visit the vertices of a graph in **search engines**	2
	PSO 2	**Select** Appropriate graph traversal techniques to visit the vertices of a graph in **mobile and web applications development**	2
	PSO 3	**Select** Appropriate graph traversal techniques to visit the vertices of a graph **in shipping real world software, using industry standard tools**	2

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	**Program Outcomes/ No. of Key Competencies Matched**												**PSO'S**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	3	2	2	3	1	-	1	2	3	-	2	2	1	1
CO 2	1	2	2	2	3	1	-	2	3	3	-	2	1	1	1
CO 3	1	2	2	1	3	1	-	-	2	3	-	2	2	2	-

CO 4	1	2	1	1	3	1	-	-	2	3	-	2	2	1	1
CO 5	1	1	2	1	3	1	-	2	2	3	-	2	2	1	1
CO 6	1	1	2	1	3	1	-	1	3	3	-	2	2	1	1

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**SEARCHING TECHNIQUES**
	Write C programs for implementing the following searching techniques. a. Linear search. b. Binary search. c. Fibonacci search.
WEEK II	**SORTING TECHNIQUES**
	Write C programs for implementing the following sorting techniques to arrange a list of integers in ascending order. a. Bubble sort. b. Insertion sort. c. Selection sort
WEEK III	**SORTING TECHNIQUES**
	Write C programs for implementing the following sorting techniques to arrange a list of integers in ascending order. a. Quick sort. b. Merge sort
WEEK IV	**IMPLEMENTATION OF STACK AND QUEUE**
	Write C programs to a. Design and implement Stack and its operations using Arrays. b. Design and implement Queue and its operations using Arrays
WEEK V	**APPLICATIONS OF STACK**
	Write C programs for the following: a. Uses Stack operations to convert infix expression into postfix expression. b. Uses Stack operations for evaluating the postfix expression
WEEK VI	**IMPLEMENTATION OF SINGLE LINKED LIST**
	Write C programs for the following: a. Uses functions to perform the following operations on single linked list. (i) Creation (ii) insertion (iii) deletion (iv) traversal b. To store a polynomial expression in memory using linked list.
WEEK VII	**IMPLEMENTATION OF CIRCULAR SINGLE LINKED LIST**
	Write C programs for the following: Uses functions to perform the following operations on Circular linked list. (i) Creation (ii) insertion (iii) deletion (iv) traversal.

WEEK VIII	**IMPLEMENTATION OF DOUBLE LINKED LIST**
	Write C programs for the following: Uses functions to perform the following operations on double linked list. (i) Creation (ii) insertion (iii) deletion (iv) traversal in both ways.
WEEK IX	**IMPLEMENTATION OF STACK USING LINKED LIST**
	Write C programs to implement stack using linked list
WEEK X	**IMPLEMENTATION OF QUEUE USING LINKED LIST**
	Write C programs to implement queue using linked list
WEEK XI	**GRAPH TRAVERSAL TECHNIQUES**
	Write C programs to implement the following graph traversal algorithms: a. Depth first search. b. Breadth first search.
WEEK XII	**IMPLEMENTATION OF BINARY SEARCH TREE**
	Write a C program that uses functions to perform the following: a. Create a binary search tree. b. Traverse the above binary search tree recursively in pre-order, post-order and in-order. c. Count the number of nodes in the binary search tree.

TEXTBOOKS

1. Rance D. Necaise, "Data Structures and Algorithms using Python", Wiley Student Edition.
2. Benjamin Baka, David Julian, "Python Data Structures and Algorithms", Packt Publishers, 2017.

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1. S. Lipschutz, "Data Structures", Tata McGraw Hill Education, 1st Edition, 2008.
2. Samanta, "Classic Data Structures", PHI Learning, 2nd Edition, 2004.Gottfried Byron,
3. "Schaum's Outline of Programming with Python", Tata Mc Graw Hill, 1st Edition, 2010.
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1. https://docs.python.org/3/tutorial/datastructures.html
2. http://interactivepython.org/runestone/static/pythonds/index.html
3. http://www.tutorialspoint.com/data-structures-algorithms
4. http://www.geeksforgeeks.org/data-structures/
5. http://www.studytonight.com/data-structures
6. http://www.coursera.org/specializations/data-structures-algorithms
7. http://cse01-iiith.vlabs.ac.in/

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Searching Techniques.	CO 1	T1
2	Sorting Techniques.	CO 2	T1
3	Sorting Techniques	CO 2	T1,T2
4	Implementation of Stack and Queue	CO 3	T1,T2
5	Applications of Stack.	CO 3	T1, W1
6	Implementation of Single Linked List	CO 4	T1,W2
7	Implementation of Circular Single Linked List.	CO 4	T1,W3
8	Implementation of Double Linked List	CO 4	T2,W3
9	Implementation of Stack Using Linked List.	CO 3,CO 4	T2,W2
10	Implementation of Queue Using Linked List	CO 3,CO 4	T2,W5
11	Graph Traversal Techniques.	CO 6	T2,W2
12	Implementation of Binary Search Tree	CO 5	T1,W5

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Twin vortex formation:** Design a Data Structure SpecialStack that supports all the stack operations like push(), pop(), isEmpty(), isFull() and an additional operation getMin() which should return minimum element from the SpecialStack. All these operations of SpecialStack must be O(1). To implement SpecialStack, you should only use standard Stack data structure and no other data structure like arrays, list, . etc.
2	**Open channel:** In class, we studied binary search trees that do not allow us to insert duplicate elements. However, sometimes we do need to store duplicates. For example, a database of student marks might contain one record for every mark by every student; so if you've taken two courses, there will be two records with the same key (your student number) and different data (your two marks). To accomplish this, we might use a data structure called a "BST with duplicates", or BSTD
3	**Capillary action:** The variable tos in the Stack class is the index of the array element that would be filled the next time push() is called. Modify the code so that tos is the index of the top element actually in use. In other words, tos is to be the index of the top array element occupied by a value that has been "pushed" onto the stack. Write your changes on the code above. Don't forget to fix the comments. You do not need to add preconditions as in part-a.
4	**Buoyancy** Given an adjacency matrix representation of a graph, describe with pseudo code an algorithm that finds a single path, if one exists, between any two different vertices.

5	**Flow through pipes:** There is a garage where the access road can accommodate any number of trucks at one time. The garage is building such a way that only the last truck entered can be moved out. Each of the trucks is identified by a positive integer (a truck-id). Write a program to handle truck moves, allowing for the following commands: a) On-road (truck-id); b) Enter-garage (truck- id); c) Exit-garage (truck-id); d) Show-trucks (garage or road); If an attempt is made to get out a truck which is not the closest to the garage entry, the error message Truck x not near garage door
6	**Flow through pipes:** How many non-null links are there in a binary tree with N nodes?
7	**Flow through pipes:** How can we remove loops in a linked list? What are the functions of fast and slow pointers?

Signature of Course Coordinator **HOD,IT**
Ms. B.Rekha, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Power Generation Systems**				
Course Code	AEE003				
Program	B.Tech				
Semester	III				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	1.5
Course Coordinator	Dr. P Mallikarjun Sharma, Professor				

I COURSE OVERVIEW:

This course deals with the basic theory, construction, operation, performance characteristics and application of electromechanical energy conversion devices such as synchronous and asynchronous machines. It also facilitates the study of the alternating machines which are the major part of industrial drives and agricultural pump sets.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS006	I	Engineering Physics

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electrical Power Generation Systems	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
70%	Understand
20%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	-	10	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
50%	50%	-

VI COURSE OBJECTIVES:

The students will try to learn:

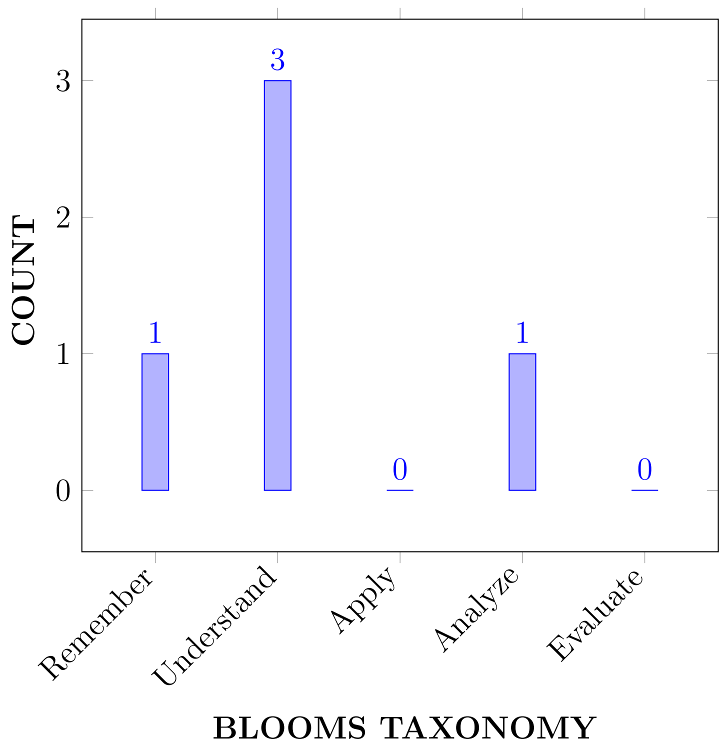
I.	Demonstrate thermal power generation systems including major subsystems.
II.	Illustrate hydroelectric power generation systems along with pumped storage plants.
III.	Understand basic working principles of nuclear power generation systems.
IV.	Apply knowledge of solar and wind power generation systems in design and implementation to obtain clean energy.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Demonstrate** the layout and working principle of thermal power plant.	Understand
CO 2	**Understand** the power developed in hydro-electric power station under various storage capacities.	Understand
CO 3	**Analyze** I-V characteristics of the solarenergy conservation and deduce the maximum power point tracking algorithm.	Analyze
CO 4	**Summarise** the performance of different generators used in wind energy systems.	Remember
CO 5	**Explain** the operating principle and applications of)nuclear power station.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE / CIE / AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	SEE / CIE / AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	SEE / CIE / AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	2	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-	-	✓		-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 4	✓	✓	-	-		-	-	-	-	-	-		✓		-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Understand the working principle of thermal power station with the **knowledge of mathematics and science.**	2
	PO 2	Identify the merits and demerits for **the validation** of thermal power station.	6
	PSO 1	Understand the operating principle of thermal power station in **the field of electrical power generation.**	5
CO 2	PO 1	Understand the layout and working principle of hydroelectric power station with basic fundamentals of **mathematics and science.**	2
	PO 2	Identify the multi-use of hydroelectric power station **using basics of mathematics and engineering sciences.**	6
	PSO 1	Understand the operation of hydroelectric power station **in the field of electrical power generation.**	5
CO 3	PO 1	Understand the concept of power generation using solar energy by photovoltaic effect with the help of **mathematics and sciences.**	2
	PO 2	Recognize the various applications of solar energy **using basics of mathematics and engineering sciences.**	6
	PSO 1	Analyze the solar power generation system using photovoltaic effect **in the field of power generation.**	5
CO 4	PO 1	Understand the operation of wind energy systems and different water turbines with the principles of **mathematics and sciences.**	2
	PO 2	Analyze the merits and demerits of wind energy systems **for validation.**	6
	PSO 1	Understand the basic concepts of wind energy systems in the field of power generation.	5
CO 5	PO 1	Understand the operating principle of nuclear power station with the use of **mathematics and science.**	2
	PO 2	Analyse the importance of nuclear power station in the field of power generation **using basics of mathematics and engineering sciences.**	6
	PSO 1	Understand the operation of nuclear power station **in the electrical power generation systems.**	5

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	4	-	-	-	-	-	-	-	-	-		4	-	-
CO 2	2	4	-	-	-	-	-	-	-	-	-	-	4	-	-
CO 3	2	4	-	-	-	-	-	-	-	-	-	-	4	-	-
CO 4	2	4	-	-		-	-	-	-	-	-		4	-	-
CO 5	2	5	-	-	-	-	-	-	-	-	-	-	3	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.6	40	-	-	-	-	-	-	-	-	-		80	-	-
CO 2	66.6	40	-	-	-	-	-	-	-	-	-	-	80	-	-
CO 3	66.6	40	-	-	-	-	-	-	-	-	-	-	80	-	-
CO 4	100	50	-	-		-	-	-	-	-	-		80	-	-
CO 5	100	50	-	-	-	-	-	-	-	-	-	-	60	-	-

XV COURSE ARTICULATION MATRIX (PO - PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	3	-	
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
TOTAL	**36**	**21**	**7**	**0**	**0**	**3**	**3**	**3**	**2**	**0**	**0**	**0**	**36**	**0**	**0**
AVERAGE	**3**	**2**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**0**

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	-
Quiz	✓	Tech - Talk	-	Certification	-
Term Paper	-	Seminars	-	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	-	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
✓	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts	-	-

XVIII SYLLABUS:

MODULE I	**THERMAL POWER STATIONS**
	Thermal Power Stations: Line diagram of thermal power station, paths of coal, steam, water, air, ash and flue gasses, description of thermal power station components, economizers, boilers, super heaters, turbines, condensers, chimney and cooling towers.
MODULE II	**HYDROELECTRIC POWER STATIONS**
	Hydroelectric Power Stations: Elements, types, concept of pumped storage plants, storage requirements, mass curve and estimation of power developed from a given catchment area, heads and efficiencies, simple problems.
MODULE III	**SOLAR ENERGY AND PHOTOVOLTAIC SYSTEMS**
	Solar Energy: environmental impact of solar power, physics of the sun, solar constant, extraterrestrial and terrestrial solar radiation, solar radiation on tilted surface, instruments for measuring solar radiation, solar radiation data, solar concentrators, collectors, thermal applications, design of standalone solar systems, simple problems. Photovoltaic systems: Photovoltaic effect, semiconducting materials, band gap theory, photo emission of electrons, cell configuration, types of solar cells, cell properties, device physics, electrostatic field across the depletion layer, voltage developed, I-V characteristics, module structure and fabrication, output power and efficiency, fill factor, maximum power point tracking (MPPT), solar grid connected inverters, simple Problems.
MODULE IV	**WIND ENERGY**
	Wind energy: Sources and potential, power from wind, Betz criterion, components of wind energy conversion system, types of turbines, horizontal and vertical axis wind turbines, aerodynamics, operational characteristics, blade element theory, types of generating systems for wind energy, permanent magnet generators, DC generators, induction generators, doubly fed induction generators, applications of wind energy, safety and environmental aspects, simple problems.

MODULE V	**NUCLEAR POWER STATIONS**
	Nuclear Power Stations: nuclear fission and chain reaction, nuclear fuels, principle of operation of nuclear reactor and components, types of nuclear reactors, pressurized water reactor, boiling water reactor and fast breeder reactor, radiation hazards, shielding and safety precautions, applications .

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1. C L Wadhawa, "Generation, Distribution and Utilization of Electrical Energy", New Age International Limited, New Delhi, 3rd Edition,2005.

2. G D Rai, "Non-Conventional Energy Sources", Khanna Publishers, 1st Edition, 2011.

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2. M V Deshpande, "Elements of Power Station Design", Prentice Hall Learning Private Limited New Delhi, 1st Edition, 1992.

3. Mukund R Patel, "Wind and Solar Power Systems", CRC Press, 1st Edition, 1999.

4. V K Mehta and Rohit Mehta, "Principle of Power Systems", S Chand and Company, Ltd, New Delhi, 3rd Edition,2005.

WEB REFFERENCES

1. https://www.NPTEL video lectures.

2. https://www.electrical4u.com

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COURSE WEB PAGE:

1. https://www.iare.ac.in/sites/default/files/Courses-description/EEE-Electrical Power Generation Systems

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Presentation on Outcome based education		
CONTENT DELIVERY (THEORY)			
2-3	Line diagram of thermal power station (TPS) showing paths of coal, steam, water, air, ash and flue gasses	CO 1	T2:1.9 R2:1.5
4-5	Brief description of TPS components: Economizers, boilers, super heaters, turbines, condensers, chimney and cooling towers	CO 1	T2:1.10 R2:1.2and1.4
6	Thermal efficiency and efficiency of TPS	CO 1	T2: 2.3-2.5 R2:1.6
7	To know Functions of super heater and condenser	CO 1	T2:1.12 R2:1.14
8	To know Description of chimney and cooling tower	CO 1	T2: 2.6 R2:1.7-1.8
9-10	To know importance of mass curve	CO 2	T2: 2.7 R2:1.12
11	To know estimation of power developed from a given catchment area	CO 2	T2: 2.6 R2:1.7-1.8
12	Elements of hydro electric power station	CO 2	T2: 1.11 R2:6.2
13	Types, concept of pumped storage plants	CO 2	T2: 10.4 R2:4.0
14	Storage requirements, mass curve (explanation only)	CO 2	T2: 10.5.1.1 R2:4.0
15-16	Estimation of power developed from a given catchment area, heads and efficiencies	CO 2	T2: 10.5.1.3 R2:4.0
17	Hydraulic turbines: Classification of turbines, impulse and reaction turbines	CO 2	T2:7.1 R2:5.2
18	Pelton wheel, Francis turbine and Kaplan turbine	CO 2	T2:7.6 R2:5.3
19-20	Working proportions, work done, efficiencies	CO 2	T2:7.2 R2:5.4
21	Hydraulic design, draft tube theory, functions and efficiency	CO 2	T2: 7.6.1 R2:5.7
22	Environmental impact of solar power, physics of the sun, solar constant, extraterrestrial and terrestrial solar radiation	CO 3	T2: 7.6.3 R2:5.10,5.11

23-24	Solar radiation on tilted surface, instruments for measuring solar radiation	CO 3	T2: 7.7 R2:5.16
25-26	Solar concentrators, collectors, thermal applications	CO 3	T2: 7.7.6 R2:5.21,5.22
27	Design of standalone solar systems	CO 3	T2:7.7.5 R2:5.20
28	Simple problems	CO 3	T2:4.1 R2:2.1
30	Photovoltaic effect, semiconducting materials, band gap theory	CO 3	T:4.5-4.6 R2:2.2
31-32	Photo emission of electrons, cell configuration, types of solar cells	CO 3	T2: 5.2.4.1 R2:3.2
33	Cell properties, device physics, electrostatic field across the depletion layer	CO 3	T2:6.5 R2:602
34	Voltage developed, I-V characteristics, module structure and fabrication	CO 3	T2: 6.6.1 R2:6.6
35	Output power and efficiency	CO 3	T2: 6.9-6.10 R2:6.13-6.15
36	Fill factor, maximum power point tracking (MPPT), solar grid connected inverters	CO 3	T2:9.3 R2:7.2
37	Simple Problems	CO3	T2: 9.3.1 R2:7.8
38	Sources and potential, power from wind, Betz criterion	CO 4	T2: 8.4 R2:7.11
39	Components of wind energy conversion system, types of turbines	CO 4	T2: 8.4 R2:7.13
40	Horizontal and vertical axis wind turbines, aerodynamics, operational characteristics	CO 4	T2: 8.8 R2:7.16
41-42	Blade element theory, types of generating systems for wind energy	CO 4	T2: 8.8 R2:7.21
43-44	Permanent magnet generators, DC generator	CO 4	T4: 4.11
45-46	Induction generators, doubly fed induction generators	CO 4	T4: 4.23 R2:8.8,8.17
47-48	Applications of wind energy, safety and environmental aspects	CO 4	T4: 4.19,5.2 R2:8.22.5
49-50	Simple Problems	CO 4	T4:4.23 R2:8.23
DISCUSSION OF DEFINITION AND TERMINOLOGY			
51-52	Terms commonly used in system operation, various factors affecting cost of generations	CO 4	T4: 6.4-6.5 R2:9.1
53-5	4 Nuclear fission and chain reaction, nuclear fuels, principle of operation of nuclear reactor	CO 5	T4: 6.6 R2:9.21,9.22

55-56	Reactor components, moderators, control rods, reflectors and coolants, radiation hazards, shielding and safety precautionss	CO 5	T4:6.3 R2:9.3
57-58	Types of nuclear reactors and brief description of PWR, BWR and FBR	CO 5	T4:6.7 R2:9.5
DISCUSSION OF QUESTION BANK			
62	THERMAL POWER STATIONS I	CO 1	T1
63	HYDROELECTRIC POWER STATIONS	CO 2,	T3
64	SOLAR ENERGY AND PHOTOVOLTAIC SYSTEMS	CO 3	T2
65	WIND ENERGY	CO 4	T2
66	NUCLEAR POWER STATIONS	CO 5	T3

Course Coordinator **HOD,EEE**
Dr V Chandra Jagan Mohan, Associate Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions	**10**

	5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**

PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project.	**12**

	6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	
PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**

PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer. 1. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**DC Machines and Transformers**				
Course Code	AEE004				
Program	B.Tech				
Semester	III				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	3	2
Course Coordinator	Mr. A Sathish Kumar				

I COURSE OVERVIEW:

This course deals with the basic theory, construction, operation, performance characteristics and application of electromechanical energy conversion devices such as DC generators and motors. It also gives an in-depth knowledge on the operation of single phase and three phase transformers and it's testing. It also focus on the auto transformers, on-load, off-load tap changers which are widely used in real time applications.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS006	II	Engineering Physics
B.Tech	AEE002	III	Electrical Circuits

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
DC Machines and Transformers	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
7%	Remember
57%	Understand
14%	Apply
21 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc.

VI COURSE OBJECTIVES:

The students will try to learn:

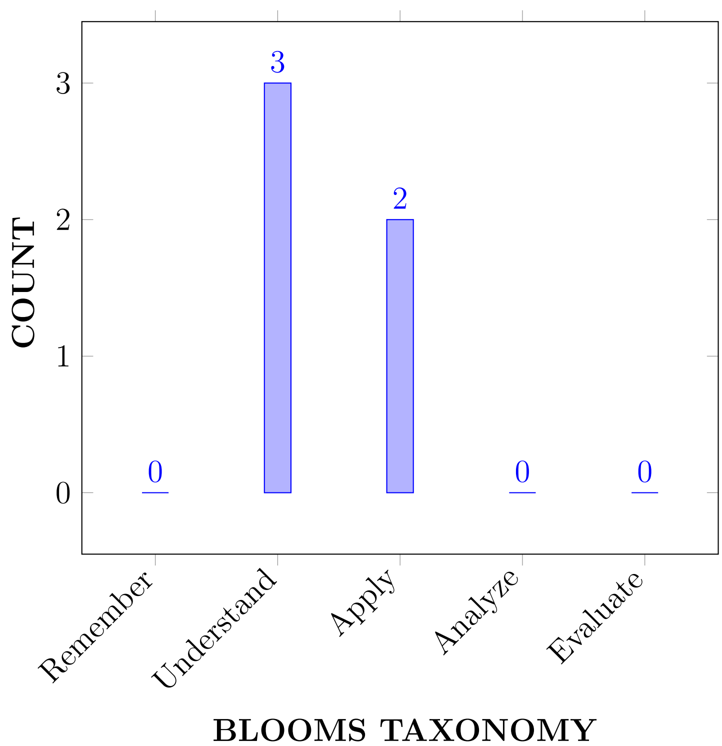
I	The principles of single excited and multiple excited systems leading to the energy balance equations.
II	The construction, working and operation of self and separately excited DC machines
III	The performance characteristics of different DC machines when they are under no load and load conditions.
IV	The energy transformation using single and poly phase transformers under no load and load conditions.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Use** the concepts of complex algebra, phasor operations, principles of electromagnetism and circuit theory . for analysing the performance related issues in electrical machines.	Apply
CO 2	**Demonstrate** the working of linear machine as generator, motor and transformer by applying electromagnetic laws and its mathematical models under different loading conditions.	Understand
CO 3	**Identify** various control strategies for calculating the performance parameters and voltage regulation of electrical machines .	Apply
CO 4	**Illustrate** the equivalent circuits and connections of three phase transformers and auto transformers for power system analysis.	Understand
CO 5	**Describe** the load sharing capabilities and reliability of electrical machines using parallel operation under various loading conditions.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE / CIE / AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	SEE / CIE / AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	SEE / CIE / AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	2	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	✓	-	-	-	-	-	-	-	-		-		-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	-		-	-	-	-	-	-		✓		-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Recall the engineering sciences** to principles of electromagnetisim and circuit theory for analysing the performance related issues in electrical machines	2
	PO 2	Validate the principles of electrical devices and design the electric machines from obtained principles using **fundamentals of mathematics and engineering sciences**	7
	PO 3	**Understand** the constructional features of DC machines using components or processes that meet the specified needs with appropriate consideration, safety considerations.	5
CO 2	PO 1	Demonstrate electromagnetic laws for the operation of DC machines with **engineering sciences**	2
	PO 2	**Understand** the operation of DC motor and DC generator using engineering sciences	4
CO 3	PO 1	Determine voltage regulation, speed control, torque and efficiency of DC machines with the knowledge of mathematics and engineering sciences	3
	PO 2	Solve the complex problems related to voltage regulation, speed control, torque and efficiency of DC machines and validate specifications of DC machines with **basics of engineering sciences and mathematics.**	5
CO 4	PO 1	Understand the connection of three phase transformer and autotransformers with the **knowledge of mathematics and engineering sciences.**	3
	PO 2	Solve the equivallent circuit parameers and voltage, current realtions of three phase transformer with the **first principles of mathematics, natural sciences, and engineering sciences.**	5
	PSO 1	Understand the connections of three phase transformer and autotransformers for smooth operation of power system	2
CO 5	PO 1	Demonstrate how load sharing of DC machine happens with their parallel operation to increase rating of power system with **knowledge of mathematics of engineering sciences.**	3
	PO 2	Calculate the electrical parameters involved in load sharing of DC machines for solving the complex problems related to parallel operation of DC machines **first principles of mathematics, natural sciences, and engineering sciences**	5

Note: For Key Attributes refer **Anexure-1**

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	7	5	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	5	-	-		-	-	-	-	-	-		2	-	-
CO 5	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.6	70	50	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.6	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.6	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.6	50	-	-		-	-	-	-	-	-		66.6	-	-
CO 5	66.6	50	-	-	-	-	-	-	-	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO - PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 -5 $<C \leq 40\%$ – Low/ Slight
2 - 40 % $<C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	2	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-		-	-	-	-	-	-		3	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	**15**	**11**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**0**
AVERAGE	**3**	**2.2**	**0.4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.6**	**0**	**0**

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Quiz	✓	Tech - Talk	-	Certification	-
Term Paper	-	Seminars	✓	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	✓	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
✓	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts	-	-

XVIII SYLLABUS:

MODULE I	**ELECTROMECHANICAL ENERGY CONVERSION**
	Electromechanical energy conversion: Forces and torque in magnetic systems, energy balance, energy and force in a singly excited and multi excited magnetic field systems, determination of magnetic force, co energy
MODULE II	**DC GENERATORS**
	DC generators: Principle of operation, construction, armature windings, lap and wave windings, simplex and multiplex windings, problems, use of laminated armature, commutator, EMF equation, types of DC generators, voltage buildup, critical field resistance and critical speed, causes for failure to self-excite and remedial measures; Armature reaction: Cross magnetization and demagnetization, ampere turns per pole, compensating winding, commutation, reactance voltage, methods of improving commutation; Characteristics: Open circuit characteristics, critical field resistance and critical speed. Load characteristics of shunt, series and compound generators; Parallel operation: Principle of parallel operation, load sharing, and use of equalizer bars, cross connection of field windings, problems.
MODULE III	**DC MOTORS AND TESTING**
	DC motors: Principle of operation, back EMF, torque equation, condition for maximum power developed, types of DC motors, armature reaction and commutation, characteristics, methods of speed control, types of starters, numerical problems; Losses and efficiency: Types of losses, calculation of efficiency, condition for maximum efficiency Testing of DC machines: Swinburnes test, brake test, regenerative testing, Hopkinsons test, fields test, retardation test and separation of stray losses, problems.
MODULE IV	**SINGLE PHASE TRANSFORMERS**
	Single phase transformers: Principle of operation, construction, types of transformers, EMF equation, concept of leakage flux and leakage reactance, operation of transformer under no load and on load, phasor diagrams, equivalent circuit, efficiency, regulation and all day efficiency; Testing of transformers: objective of testing, polarity test, measurement of resistance, OC and SC tests, back to back test, heat run test, parallel operation, problems.
MODULE V	**POLY PHASE TRANSFORMERS**
	Three phase transformer: Principle of operation, star to star, delta to delta, star to delta, delta to star, three phase to six phase, open delta connection, Scott connection; Auto transformers: Principles of operation, equivalent circuit, merits and demerits, no load and on load tap changers, harmonic reduction in phase voltages, cooling methods of transformers problems.

TEXTBOOKS

1. A E Fitzgerald and C Kingsley, ”Electric Machinery”, McGraw Hill Education, 2013.

2. P S Bimbhra, “Electrical Machinery”, Khanna Publishers, 2011.

3. I J Nagrath and D P Kothari, “Electric Machines”, McGraw Hill Education, 2010.

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1. M G Say, “Alternating Current Machines”, Pitman Publishing Ltd, 4th Edition, 1976.
2. P C Sen, “Principles of Electric Machines and Power Electronics”, John Wiley & Sons, 2007.
3. S K Bhattacharya, “Electrical Machines”, TMH publication, 2nd Edition, 2006.

WEB REFFERENCES

1. https://www.electricaltechnology.org
2. https://www.cet.edu.in
3. https://gndec.ac.in

COURSE WEB PAGE:

1. https://www.iare.ac.in/sites/default/files/Courses-description/EEE - Electrical machines -I

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO’s	Reference
OBE DISCUSSION			
1	Presentation on Outcome based education		
CONTENT DELIVERY (THEORY)			
1	Review of magnetic circuits and basic definitions.	CO 2	T1:4.1-4.2
2	Visualization of magnetic fields produced by a bar magnet and a current carrying coil through air and through a combination of iron and air.	CO 2	T1:4.1-4.2
3	Forces and torque in magnetic systems, energy and force in a singly excited magnetic field systems, determination of magnetic force, co- energy.	CO 2	T1:4.1-4.2
4	Understand principle of operation of DC generator.	CO 2	T1:4.1-4.2
5	Know the different parts in a DC machine and understand the functioning of each component..	CO 1	T1:4.3
6	Know the different types of windings used in DC generators.	CO 1	T1:4.4-4.9
7	Understand why the core of a DC machine is laminated and functioning of commutator	CO 1	T1:4.3
8	Derive the equation of EMF induced in a DC generator and solve the simple problems	CO 1	T1:4.10
9	Distinguish the different types of DC generators and know how the voltage is buildup in DC generators	CO 1	T1:6.1-6.2
10	Distinguish the different types of DC generators and know how the voltage is buildup in DC generators.	CO 1	T1:6.1-6.2

11	Problems on the different types of DC generators.	CO 1	T1:6.1-6.2
12	Problems on the different types of DC generators.	CO 1	T1:6.1-6.2
13	Understand the concept of critical field resistance and critical speed.	CO 3	T1:6.7-6.12
14	Understand the different causes for the failure of excitation in DC generators and know the remedies to solve the problem	CO 3	T1:6.13-6.14
15	Understand the concept of armature reaction in DC generator	CO 1	T1:5.1-5.2
16	Understand the concept of cross magnetization and demagnetization in DC generator	CO 1	T1:5.3
17	Solve the problems on armature reaction	CO 1	T1:5.7
18	Understand the concept of commutation, and know different methods used for improving the commutation	CO 1	T1:5.4-5.6
19	Draw the different types of characteristics for DC generators	CO 3	T1:6.5-6.11
20	Understand the basic principle of operating the generators in parallel	CO 5	T1:7.1 -7.4
21	Understand the function of equalizer bar and its usage	CO 1	T1:7.2
22	Solve the different types of numerical problems related to DC generators.	CO 1	T1:4.1-7.4
23	Understand the basic principle of dc motor and its function	CO 1	T1:8.2
24	Understand how the back EMF is induced in DC motor and derive the torque equation.	CO 1	T1:8.4-8.6
25	Know different types of motors and solve simple problems.	CO 1	T1:8.7.1-8.7.5
26	Understand the occurrence of armature reaction and study the commutation techniques	CO 1	T1:8.16
27	Draw the performance characteristics of DC motors	CO 3	T1:8.18-8.23
28	Understand the methods of speed control	CO 3	T1:9.1-9.3
29	Know why starters are used and different types of starters	CO 3	T1:9.4-97
30	Understand the differ types of losses that are occurred in a DC motor.	CO 1	T1:10.1-10.4
31	Solve different numerical problems related to efficiency of DC motor	CO 3	T1:10.1-10.4
32	Conduct the Swinburnes test and Brake test on DC motor and compare the two methods	CO 3	T1:10.7
33	Conduct the regenerative test, Hopkinsons test and determine the efficiency of DC motor	CO 3	T1:10.8
34	Conduct the fields test on DC series motor, and retardation test on DC shunt motor	CO 3	T1:10.9-10.1
35	Summarize the different types of losses and separate the each loss from total losses	CO 3	T4:10.10

36	Solve the different types of numerical problems related to DC motors testing	CO 1	T1:8.2-10.10
37	Explain the operation, construction and types of single phase transformer	CO 1	T1:1.1-1.4, T1:1.24
38	Derive the equation of EMF induced in transformer and understand the concept of leakage flux and reactance	CO 1	T1:1.5-1.6
39	Discuss the operation of transformer under no load and on load with the phasor diagrams	CO 1	T1:1.8-1.12
40	Draw the equivalent circuit of single phase transformer and study the concept of regulation and all day efficiency	CO 3	T1:1.13-1.18
41	Solve the Numerical problems on EMF equation and draw the phasor diagrams	CO 3	T1:1.1-1.18
42	Understand the objectives of testing, and kwon how to conduct polarity test and how to measure resistance	CO 3	T1:1.19.1-1.19.2
43	Conduct OC and SC tests on transformer and determine the efficiency and regulation at different loads	CO 3	T1:1.193-1.195
44	Conduct back to back test / heat run test and determine the efficiency and regulation	CO 3	T1:1.19.6
45	Solve the problems on transformer testing	CO 3	T1:1.19.1-1.19.6
46	Understand the necessity and importance of parallel connection of transformers	CO 5	T1:10.3.1
47	Solve the different types of numerical problems related to single phase transformers	CO 1	T1:1.1-2.11
48	Understand the principle of operation of three phase transformers	CO 4	T1:2.1-2.2
49	Analyze the different connections of three phase transformers	CO 4	T1:2.3.1-2.3.2
50	Solve the problems on three phase transformer connections	CO 4	T1:2.1-2.3.2
51	Analyze how a transformer can work on open delta connection	CO 4	T1:2.4.1-2.4.2
52	Describe how scott connection is performed to convert three phase supply to two phase and vice versa	CO 4	T1:2.5
53	Understand the principle of operation auto transformers	CO 4	T1:2.12
54	Draw the equivalent circuit and explain the merits and demerits of auto transformers	CO 4	T1: 2.12.2
55	Solve the problems on Autotransformers	CO 4	T1: 2.12.2
56	Understand the operation of no load and on load tap changers	CO 4	T1:1.17.1-2.17.2
57	Know how to reduce the harmonics in phase voltages	CO 4	T1:2.62
DISCUSSION OF DEFINITION AND TERMINOLOGY)			
58	Discussion on Question bank and definition terminology of Electromechanical Energy Conversion	CO 2	T1:4.4-4.9

59	Discussion on Question bank and definition terminology of DC Generators	CO 1, CO 2, CO 3, CO 5	T1:8.2-10.10
60	Discussion on Question bank and definition terminology of DC motors and performance of dc machines	CO 1, CO 2, CO 3, CO 5	T1:1.1-1.18
61	Discussion on Question bank and definition terminology of single phase transformers	CO 1, CO 2, CO 3, CO 5	T1:2.4.1-2.4.2
62	Discussion on Question bank and definition terminology of poly phase transformers	CO 4	T1:1.17.1-2.17.2
DISCUSSION OF QUESTION BANK			
63	Module I	CO 2	T2: 3.2-3.3
64	Module -II	CO 1, 2, 3, 5	T3: 6.9-6.14
65	Module - III	CO 1, 2 ,3 , 5	T2: 5.1-5.20
66	Module - IV	CO 1, 2 ,3 ,5	T2: 7.1-7.20
67	Module - V	CO 4	T3:36.8

Course Coordinator **HOD,EEE**
Mr A Sathish Kumar, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions	**10**

	5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**

PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project.	**12**

	6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	
PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**

PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer. 1. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Network Analysis**				
Course Code	AEE005				
Program	B.Tech				
Semester	III				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	3	2
Course Coordinator	Dr. D Shobha Rani, Professor, EEE				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS002	I	Linear Algebra and Ordinary Differential Equations
B.Tech	AHS011	II	Mathematical Transform Techniques
B.Tech	AEE002	II	Electrical Circuits

II COURSE OVERVIEW:

This course introduces the basic concepts of net work theory which is the foundation for all subjects of the electrical engineering discipline. The emphasis of this course is laid on the basic analysis of circuits which includes three phase circuits, transient analysis of DC and AC circuits, network functions, and two port net work parameters, Fourier analysis of AC circuits, design and analysis of filters.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Network Analysis	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
66.67 %	Understand
33.33%	Apply
%	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving

40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

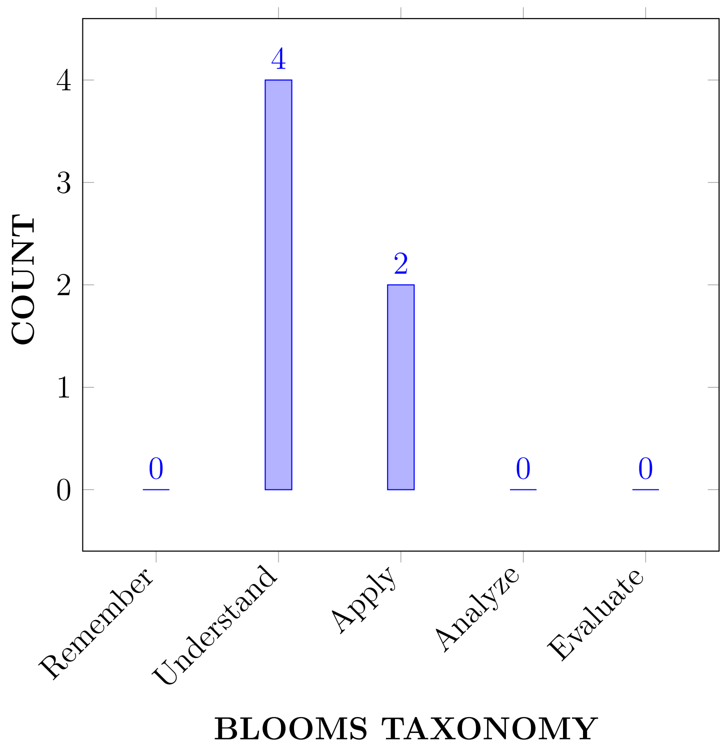
I	Analyse three phase star and delta connected circuits to calculate the active and reactive power.
II	Understand the transient response of series and parallel RL, RC and RLC circuits for DC and AC excitations.
III	Discuss the concepts of locus diagram, network functions and to calculate the two port network parameters.
IV	Design different types of filters and perform the digital simulation of electric circuits.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Understand** the relation between line and phase quantities of three phase star and delta connected systems to analyze balanced and unbalancedcircuits.	Understand
CO 2	**Demonstrate** the operation of wattmeter to measure the three-phase active and reactive power in three phase systems.	Understand
CO 3	**Understand** the concept of initial conditions of RLC elements to determine the transient response of first and second order electric circuits using differential equation approach and Laplacetransform technique.	Understand
CO 4	**Illustrate** the locus diagram for series and parallel circuits and describe the network functions in time domain and frequency domain approach.	Understand
CO 5	**Solve** the various two port network parameters and determine their inter relationships,outline the concepts of interconnections of two port networks.	Apply
CO 6	**Develop** the various types of active filters and understand their characteristics, execute digital simulation using MATLAB.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

Program Outcomes	
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	AAT/CIE/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	AAT/CIE/SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	1	Quiz

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	-		-	-	-	-	-	-		-	✓	-
CO 5	✓	-	-	-	-	-	-	-	-	-	-	-	-	✓	-
CO 6	✓	✓	-	-		-	-	-	-	-	-	-	-	✓	

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Recall the engineering sciences** to understand sline and phase quantities of three phase star and delta connected systems	3
CO 2	PO 1	**Recall the engineering sciences** to understand three-phase active and reactive power in three phase systems	3
	PO 2	Develop the equation for measure the three-phase active and reactive power in three phase systems with help of basic mathematics and engineering sciences.	2
CO 3	PO 1	**Recall the engineering sciences** to understand the concept of initial conditions of RLC elements to determine the transient response	3
	PO 2	Develop the solutions for initial conditions of RLC elements to determine the transient response of first and second order electric circuits with help of basic mathematics and engineering sciences.	2
CO 4	PO 1	**Recall the engineering sciences** to understand locus diagram for series and parallel circuits	3
	PO 2	Develop the the network functions in time domain and frequency domain approach using which complex engineering problems can be solved with help of basic mathematics and engineering sciences.	2
	PSO 2	Understand the locus diagram for series and parallel circuits	1
CO 5	PO 1	**Recall the engineering sciences** to understand the concepts of interconnections of two port networks.	3
	PSO 2	Understand the various two port network parameters and their inter relationships	1
CO 6	PO 1	**Recall the engineering sciences** to understand the filter characteristics	3
	PO 2	Develop the various types of active filters using which complex engineering problems can be solved with help of basic mathematics and engineering sciences.	2
	PSO 2	Understand the active filters characteristics, execute digital simulation using MATLAB	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-		-	-	-	-	-	-		-	1	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	-	1	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	100	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	50	-	-		-	-	-	-	-	-		-	50	-
CO 5	100	-	-	-	-	-	-	-	-	-	-	-	-	50	-
CO 6	100	50	-	-		-	-	-	-	-	-		-	50	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	-	2	-
TOTAL	18	8	-	-	-	-	-	-	-	-	-	-	-	6	-
AVERAGE	3	2	-	-	-	-	-	-	-	-	-	-	-	2	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**THREE PHASE CIRCUITS**
	Three Phase Circuits: Star and delta connections, phase sequence, relation between line and phase voltages and currents in balanced star and delta circuits, three phase three wire and three phase four wire systems, shifting of neutral point, analysis of balanced and unbalanced three phase circuits, measurement of active and reactive power.
MODULE II	**DC AND AC TRANSIENT ANALYSIS**
	Transient response: Initial conditions, transient response of RL, RC and RLC series and parallel circuits with DC and AC excitations, differential equation and Laplace transform approach.
MODULE III	**LOCUS DIAGRAMS AND NETWORKS FUNCTIONS**
	Locus Diagrams: Elementary treatment of locus diagrams of RL, RC and RLC circuits (series and parallel combinations). Network Functions: The concept of complex frequency, physical interpretation, transform impedance, series and parallel combination of elements, terminal ports, network functions for one port and two port networks, poles and zeros of network functions, significance of poles and zeros, properties of driving point functions and transfer functions, necessary conditions for driving point functions and transfer functions, time domain response from pole-zero plot.
MODULE IV	**TWO PORT NETWORK PARAMETERS**
	Two Port Network Parameters: Z, Y, ABCD, hybrid and inverse hybrid parameters, conditions for symmetry and reciprocity, inter relationships of different parameters, interconnection (series, parallel and cascade) of two port networks, image parameters.
MODULE V	**FILTERS AND DIGITAL SIMULATION OF CIRCUITS**
	Filters: Low pass, high pass, band pass, band elimination filters, introduction to active filter, filter design. Digital Simulation: MATLAB simulation and mathematical modeling of R, RL, RC and RLC circuits with DC and AC excitations: steady state and transient analysis, time and frequency domain analysis, frequency and phase spectra by Fourier analysis; basic test signals representation, filter design.

TEXTBOOKS

1. A Chakrabarthy, “Electric Circuits”, Dhanpat Rai Sons, 6th Edition, 2010.

2. A Sudhakar, Shyammohan S Palli, “Circuits and Networks”, Tata McGraw-Hill, 4th Edition, 2010
3. M E Van Valkenberg, “Network Analysis”, PHI, 3rd Edition, 2014.
4. Rudrapratap, “Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers”, Oxford University Press, 1st Edition, 1999.

REFERENCE BOOKS:

1. John Bird, “Electrical Circuit Theory and technology”, Newnes, 2nd Edition, 2003
2. C L Wadhwa, “Electrical Circuit Analysis including Passive Network Synthesis”, New Age International, 2nd Edition, 2009.
3. David A Bell, “Electric Circuits”, Oxford University Press, 7th Edition, 2009.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112105171/1

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=courses/electrical-and-electronics-engineering-autonomous/network-analysis

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO’s	Reference T1: 4.1
OBE DISCUSSION			
0	OBE DISCUSSION		
CONTENT DELIVERY (THEORY)			
1	Interpret three phase circuits, its generation and connections.	CO 1	T2:9.3 R1:19.1
2	Discriminate three phase circuits when connected in star and delta.	CO 1	T2: 9.6 R2:19.4
3	Analyze the three phase loads	CO 1	T2: 9.7 R2:19.5
4	Discuss voltage and current of three phase unbalanced loads.	CO 1	T2: 9.10 R2:19.6
5	Determine the active power in a three phase circuit and the effect of power factor on Wattmeter readings.	CO 1	T2: 9.11 R2:19.8
6	Determine the reactive power in a three phase circuit	CO 1	T2: 9.11 R2:19.8
7	Observe the Transient behavior of R, L and C elements in a circuit.	CO 2	T2 - 11.1 R2 :17.1
8	Compute initial conditions and time response for current and voltage in first order R-L and R-C circuits	CO 2	T2 :11.2 R2 :17.3
9	Analyze and solve problems on complicated RC and RL circuits	CO 2	T2 :11.2 R2:17.12

10	Describe the AC Transient analysis of a series RC, RL circuits	CO 2	T2:11.5 R2:17.5
11	Analyze Transient behavior of a series RLC circuits to AC excitation	CO 2	T2 - 11.7 R2:17.6
12	Analyze the Transients using Laplace transform method	CO 2	T2 :11.7 R2:17.10
13	Discuss the concepts of locus diagram	CO 3	T2 – 8.13 R2:15.12
14	Learn about complex frequency	CO 3	T2 – 15.1 R2:15.1
15	Design Transform Impedance and Transform Circuits	CO 3	T2 – 15.3 R2:15.1
16	Learn terminal pairs or ports	CO 3	T2 – 15.5 R2:15.1
17	Study the significance of poles and zeros	CO 3	T2 – 15.8 R2:15.1
18	Understand the properties of Transfer functions, Necessary conditions for driving point functions	CO 3	T2 :15.14 R2:15.1
19	Study the Necessary conditions for transfer functions, time domain response from pole zero plot	CO 3	T2 :15.14 R2:15.1
20	Discuss about network parameters	CO 4	T1 :13.6 R2:16.3
21	Obtain Z parameters and Y parameters	CO 4	T1 :13.6 R2:16.4
22	Analyze problems on Z and Y parameters	CO 4	T1 :13.9 R2:16.5
23	Design h parameters and ABCD parameters	CO 4	T1 :13.6
24	Analyze problems on h and ABCD parameters	CO 4	T1 :13.6 R2:16.7
25	Interrelate Z, Y, H , T parameters	CO 4	T1 :13.7 R2:16.8
26-28	Study the Cascade, series, parallel connection of Networks	CO 4	T1 :13.14 R2:16.9
28	Understand the Low Pass filter characteristics and design	CO 5	T1: 18.6 R2:19.12
29	Design the High Pass filter and study its characteristics	CO 5	T1 :18.8 R2:19.2
30	Analyze and Design Band Pass filter	CO 5	T1 :18.8 R2:19.3
31-32	Understand the characteristics of Band Elimination filter	CO 5	T1 :18.14 R2:19.4
33	Design of Active filters	CO 5	T1 :18.17 R2:19.3
34-37	Observe the simulation of RL,RC,RLC circuits	CO 5	T2 :11.7 R2:14.3
38-40	Demonstrate different properties of Fourier transforms	CO 5	T2 :12.1 R2:14.5
PROBLEM SOLVING/ CASE STUDIES			

41	Analyze the three phase loads	CO 1	T2: 9.7 R2:19.5
42	Discuss voltage and current of three phase unbalanced loads.	CO 1	T2: 9.10 R2:19.6
43	Determine the active power in a three phase circuit and the effect of power factor on Wattmeter readings.	CO 1	T2: 9.11 R2:19.8
44	Compute initial conditions and time response for current and voltage in first order R-L and R-C circuits	CO 2	T2 :11.2 R2 :17.3
45	Analyze and solve problems on complicated RC and RL circuits	CO 2	T2 :11.2 R2:17.12
46	Describe the AC Transient analysis of a series RC, RL circuits	CO 2	T2:11.5 R2:17.5
47	Design Transform Impedance and Transform Circuits	CO 3	T2 – 15.3 R2:15.1
48	Learn terminal pairs or ports	CO 3	T2 – 15.5 R2:15.1
49	Study the significance of poles and zeros	CO 3	T2 – 15.8 R2:15.1
50	Analyze problems on h and ABCD parameters	CO 4	T1 :13.6 R2:16.7
51	Interrelate Z, Y, H , T parameters	CO 4	T1 :13.7 R2:16.8
52	Study the Cascade, series, parallel connection of Networks	CO 4	T1 :13.14 R2:16.9
53	Design the High Pass filter and study its characteristics	CO 5	T1 :18.8 R2:19.2
54	Analyze and Design Band Pass filter	CO 5	T1 :18.8 R2:19.3
55	Understand the characteristics of Band Elimination filter	CO 5	T1 :18.14 R2:19.4
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Discriminate three phase circuits when connected in star and delta.	CO 1	T2: 9.6 R2:19.4
57	Observe the Transient behavior of R, L and C elements in a circuit.	CO 2	T2 - 11.1 R2 :17.1
58	Discuss the concepts of locus diagram	CO 3	T2 – 8.13 R2:15.12
59	Obtain Z parameters and Y parameters	CO 4	T1 :13.6 R2:16.4
60	Analyze and Design Band Pass filter	CO 5	T1 :18.8 R2:19.3
DISCUSSION OF QUESTION BANK			
1	Module I	CO 1	R4:2.1
2	Module II	CO 2	T4:7.3
3	Module III	CO 3	R4:5.1
4	Module IV	CO 4	T1:7.5
5	Module V	CO 5	T1: 4.1

Signature of Course Coordinator **HOD,EEE**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

<table>
<tr><td>Department</td><td colspan="5">ELECTRICAL AND ELECTRONICS ENGINEERING</td></tr>
<tr><td>Course Title</td><td colspan="5">Electromagnetic Field Theory</td></tr>
<tr><td>Course Code</td><td colspan="5">AEE006</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td colspan="5">III</td></tr>
<tr><td>Course Type</td><td colspan="5">CORE</td></tr>
<tr><td>Regulation</td><td colspan="5">R16</td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>3</td><td>1</td><td>4</td><td>-</td><td>-</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Dr.Sayanti Chatterjee, Associate Professor</td></tr>
</table>

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSC02	I	Linear Algebra Calculus
B.Tech	AHSC03	I	Engineering Physics

II COURSE OVERVIEW:

This course will equip the students with good understanding of underlying principles and laws in electromagnetic fields and waves. The concepts of vector algebra, principles and basic laws of electrostatics, characteristics and properties of conductors and dielectrics, behavior of static magnetic field and application of Ampere's law, determination of force in magnetic field and magnetic potential, concept of time varying fields and propagation of electro-magnetic waves.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electromagnetic Field Theory	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

<table>
<tr><td>✓</td><td>Power Point Presentations</td><td>✓</td><td>Chalk & Talk</td><td>✓</td><td>Assignments</td><td>x</td><td>MOOC</td></tr>
<tr><td>x</td><td>Open Ended Experiments</td><td>x</td><td>Seminars</td><td>x</td><td>Mini Project</td><td>x</td><td>Videos</td></tr>
<tr><td>x</td><td colspan="7">Others</td></tr>
</table>

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
50 %	Understand
50 %	Apply
0%	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

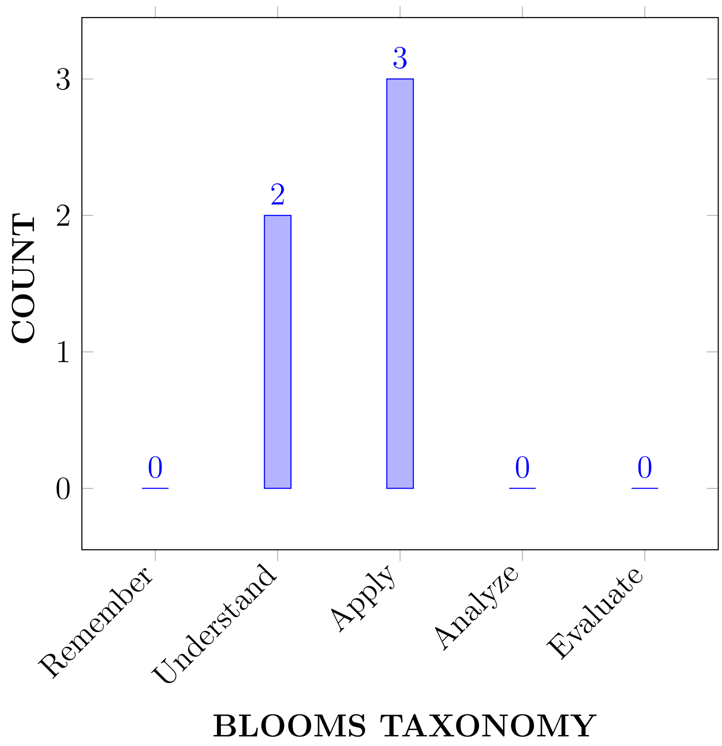
I	The behavior of charge under rest with static electric field in terms of electric field intensity, electric displacement and electric potential.
II	The charge distribution in conductors, dielectrics and condensers.
III	The sources to study the effect of static and dynamic fields in terms of magnetic field intensity, displacement and potential.
IV	The nature of electromagnetic wave propagation in free space, conductors and dielectric materials.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Make use of** Vector Calculus, Coulomb's Law and Gauss Law for obtaining electric field intensity, Potential and behavior of electrostatic field	Apply
CO 2	**Calculate** the capacitance of different physical configuration based on the behavior of the conductors and dielectric materials.	Apply
CO 3	**Demonstrate** Biot-Savart law and Ampere circuital law for derivation of magnetic field intensity due to different current carrying conductors.	Understand
CO 4	**Predict** the force due to moving charge/current in the static magnetic field, thereby obtaining the inductance for different configurations of wires and energy stored in the coil	Understand
CO 5	**Apply** the Faraday's law of Electromagnetic induction and Maxwell Equations to produce a wave equation for the free- space, insulators and conductors for propagation of electromagnetic waves.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Program Outcomes	
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/Quiz/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	CIE/Quiz/AAT
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	CIE/Quiz/AAT
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	1	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.	3	Quiz

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	✓	✓	-	-	-	-	-	✓	-	✓	✓	-	-
CO 2	✓	✓	✓	✓	-	-	-	-	-	✓	-	✓	✓	-	-
CO 3	✓	✓	✓	✓	-	-	-	-	-	✓	-	✓	✓	-	-
CO 4	✓	✓	✓	✓	-	-	-	-	-	✓	-	✓	✓	-	-
CO 5	✓	✓	✓	✓	-	-	-	-	-	✓	-	✓	✓	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recollect the basics of matter , types of charge distribution and vector analysis for solving the force and electric field intensity using **the knowledge of mathematics, science, and engineering fundamentals.**	3
	PO 2	Determine the standard expressions for electric filed intensity , torque, Potential due to line, surface and volume charge distributions **to analyze complex engineering problems using principles of mathematics and engineering sciences.**	10
	PO 3	Design the basic electrical components using **principles and laws of electromagnetic to meet the required specifications**	5
	PO 4	Understand the knowledge of electric field and potential **to analyze complex engineering problems using principles of mathematics and engineering sciences for future research.**	2
	PO 10	Students are given teck-talk and concept video **to improve their communication skills towards scientific discussion.**	1
	PO 12	Vector algebra, electromagnetic field and poential helps **in lifelong learning in significant skills.**	2
	PSO 1	Make use of Coloumb's law in structuring the principles of electrostatic instruments using in system for **generation, transmission and distribution of power.**	1
CO 2	PO 1	Understand the behavior of conductors and dielectrics with the **knowledge of mathematics, science and engineering fundamentals** for capacitance calculation.	3
	PO 2	Derive the standard expression for different configured capacitors to **analyse complex engineering problems be framed using basics of mathematics and engineering sciences**	10
	PO 3	Determine capacitance of power system equipments to design electrical components at specifications of **different stages to meet the required**	5
	PO 4	Understand the knowledge of current ,conductor and dielectric **to analyze complex engineering problems using principles of mathematics and engineering sciences for future research.**	8
	PO 10	Students are given teck-talk and concept video **to improve their communication skills towards scientific discussion.**	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 12	Capacitor, dielectric etc. helps **in lifelong learning in significant skills.**	4
	PSO 1	Recognize the importance of conductors and dielectrics in **generation, transmission and distribution of power.**	1
CO 3	PO 1	**Use the basics of mathematics, science and engineering fundamentals** for obtaining magnetic field intensity and magnetic flux density	3
	PO 2	Standard expressions of magnetic field intensity and density with helps in **solving complex engineering problems.**	7
	PO 3	Design the characteristics of magnetic field using bio savart and ampere laws which helps in **obtaining the desired specifications of electrical components.**	5
	PO 4	Understand the knowledge of magnetic field intensity and magnetic flux density **to analyze complex engineering problems using principles of mathematics and engineering sciences for future research.**	2
	PO 10	Students are given teck-talk and concept video **to improve their communication skills towards scientific discussion.**	1
	PO 12	characteristics of magnetic field using bio savart and ampere laws which helps in **tin lifelong learning in significant skills.**	2
	PSO 1	Understand the characteristics of magnetic field the structure using **principles of electrical equipment in power systems.**	1
CO 4	PO 1	Type of force due to different configured conductors and their inductances with the help of **basic fundamentals of mathematics science and engineering fundamentals.**	3
	PO 2	Develop the standard expressions of self and mutual inductance for different shaped coils by **identifying different coil configuration**	7
	PO 3	Solve the self and mutual inductance of complex engineering problems **to obtain the desired specifications of electrical component in power system.**	5
	PO 4	Understand the knowledge of magnetic field intensity and magnetic flux density **to analyze complex engineering problems using principles of mathematics and engineering sciences for future research.**	2
	PO 10	Students are given teck-talk and concept video **to improve their communication skills towards scientific discussion.**	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 12	characteristics of magnetic field using bio savart and ampere laws which helps in **tin lifelong learning in significant skills.**	2
	PSO 1	Summarize the features of coils their by constructing the various **types of windings for required output from electrical machines in power system.**	1
CO 5	PO 1	Make use of expressions obtained during analysis of electrostatics and magneto statics fields their deducing the same for time varying fields using **knowledge of mathematics , science and engineering fundamentals.**	3
	PO 2	Interpret the solution of complex problems on time varying fields and obtain some standard conclusion on properties of time varying fields using **to analyse the behaviour of time varying field**	7
	PO 3	Obtain the standard expressions for electromagnetic wave propagation in free space, insulators and conductors to conclude solution of complex engineering problems to **develop the solutions of different medium**	7
	PO 4	Understand the knowledge of electromagnetic field intensity and magnetic flux density **to analyze complex engineering problems using principles of mathematics and engineering sciences for future research.**	2
	PO 10	Students are given teck-talk and concept video **to improve their communication skills towards scientific discussion.**	1
	PO 12	characteristics of electromagnetic field using Faraday and Maxwell's laws which helps in **tin lifelong learning in significant skills.**	2
	PSO 1	Build the electrical machinery and components based on **Faraday's law of electromagnetic induction, Maxwell's Law and wave propagation, at different modes of power system.**	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	10	5	2	-	-	-	-	-	1	-	2	2	-	-
CO 2	3	10	5	8	-	-	-	-	-	1	-	4	2	-	-
CO 3	3	7	7	6	-	-	-	-	-	1	-	4	2	-	-
CO 4	3	7	5	6	-	-	-	-	-	1	-	4	2	-	-
CO 5	3	7	7	8	-	-	-	-	-	1	-	2	2	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	100	50	18	-	-	-	-	-	20	-	25	50	-	-
CO 2	100	100	50	72	-	-	-	-	-	20	-	25	50	-	-
CO 3	100	70	70	54	-	-	-	-	-	20	-	50	50	-	-
CO 4	100	70	50	54	-	-	-	-	-	20	-	50	50	-	-
CO 5	100	70	70	80	-	-	-	-	-	20	-	25	50	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\ \% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	2	1	-	-	-	-	-	1	-	1	2	-	-
CO 2	3	3	2	3	-	-	-	-	-	1	-	2	2	-	-
CO 3	3	3	3	2	-	-	-	-	-	1	-	2	2	-	-
CO 4	3	3	2	2	-	-	-	-	-	1	-	2	2	-	-
CO 5	3	3	3	3	-	-	-	-	-	1	-	1	2	-	-
TOTAL	15	15	12	11	-	-	-	-	-	5	-	8	10	-	-
AVERAGE	3	3	2.4	1.2	-	-	-	-	-	1	-	1.6	2	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams		SEE Exams		Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 4	Open Ended Experiments	-
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**ELECTROSTATICS**
	Introduction to Cartesian, cylindrical and spherical co-ordinates. Conversion of one type of coordinates to another; Electrostatic fields: Coulomb's law, electric field intensity due to line and surface charges, work done in moving a point charge in an electrostatic field, electric potential, properties of potential function, potential gradient, Gauss's law, application of Gauss's law, Maxwell's first law, Laplace's and Poisson's equations, solution of Laplace's equation in one variable
MODULE II	**CONDUCTORS AND DIELECTRICS**
	Dipole moment, potential and electric field intensity due to an electric dipole, torque on an electric dipole in an electric field, behavior of conductors in an electric field, electric field inside a dielectric material, polarization, conductor and dielectric, dielectric boundary conditions, capacitance of parallel plate and spherical and coaxial capacitors with composite dielectrics, energy stored and energy density in a static electric field, current density, conduction and convection current densities, Ohm's law in point form, equation of continuity.
MODULE III	**MAGNETOSTATICS**
	Biot-Savart's law, magnetic field intensity, magnetic field intensity due to a straight current carrying filament, magnetic field intensity due to circular, square and solenoid current carrying wire, relation between magnetic flux, magnetic flux density and magnetic field intensity, Maxwell's second equation, div(B)=0. Magnetic field intensity due to an infinite sheet of current and a long current carrying filament, point form of Ampere's circuital law, Maxwell's third equation, Curl (H)=Jc, field due to a circular loop, rectangular and square loops.
MODULE IV	**FORCE IN MAGNETIC FIELD AND MAGNETIC POTENTIAL**
	Moving charges in a magnetic field, Lorentz force equation, force on a current element in a magnetic field, force on a straight and a long current carrying conductor in a magnetic field, force between two straight long and parallel current carrying conductors, magnetic dipole and dipole moment, a differential current loop as a magnetic dipole, torque on a current loop placed in a magnetic field; Vector magnetic potential and its properties, vector magnetic potential due to simple configurations, Poisson's equations, self and mutual inductance, Neumann's formula, determination of selfinductance of a solenoid, toroid and determination of mutual inductance between a straight long wire and a square loop of wire in the same plane, energy stored and density in a magnetic field, characteristics and applications of permanent magnets.
MODULE V	**TIME VARYING FIELDS AND FINITE ELEMENT METHOD**
	Faraday's laws of electromagnetic induction, integral and point forms, Maxwell's fourth equation, , statically and dynamically induced EMFs, modification of Maxwell's equations for time varying fields, displacement current. Derivation of Wave Equation, Uniform Plane Waves, Maxwell's equation in phasor form, Wave equation in Phasor form, Plane waves in free space and in a homogenous material. Wave equation for a conducting medium, Plane waves in loss dielectrics, Propagation in good conductors, Skin effect. Poynting theorem.

TEXTBOOKS

1. K.B. MadhuSahu, " Eelectromagnetic Fields", Scitech Ltd., 2nd Edition.
2. David J Griffiths, "Introduction to Electrodynamics" Pearson Education Ltd., 4th Edition, 2014.
3. Sunil Bhooshan, "Fundamentals of Engineering Electromagnetics", Oxford University Press, st Edition, 2012.
4. E Kuffel, W S Zaengl, J Kuffel, "High Voltage Engineering Fundamentals", Newnes, 2nd Edition, 2000.

REFERENCE BOOKS:

1. Matthew N O Sadiku, S V Kulkarni, "Principles of Electromagnetics", Oxford University Press,6th Edition, 2015.
2. AS Mahajan , AA Rangwala "Electricity And Magnetism", McGraw Hill Publications, 1st Edition, 2000.
3. MS Naidu, V Kamaraju "High Voltage Engineering", McGraw Hill Publications, 3rd Edition, 2013.
4. William H Hayt, John A Buck, "Problems and Solutions in Electromagnetics", McGraw Hill Publications, 1st Edition, 2010.

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1			
CONTENT DELIVERY (THEORY)			
1	Introduction to vector algebra	CO1	T1: 1.12, RR4:1.1-1.8
2	Analysis and conversion of different types of co-ordinates	CO1	T1: 2.4-2.5, R2:2.9-3.3
3	Introduction to electro static fields and coulomb's Law	CO1, CO3	T1:2.16-2.17, R2:2.9-2.10
4	Derive the work done in moving a point charge in an electrostatic field	CO2, CO3	T1:2.13-2.14, R2:2.11

5	State Gauss's law and application of Gauss's law.	CO1	T1:2.20-2.21, R2:3.5
6	Deduce Maxwell's first law.	CO1	T1: 3.1-3.4,R2: 3.7
7	Determine the solution of Laplace's equation in one variable	CO1	T1:4.1-4.5, R2:4.1,5.1
8	Derive the Laplace's and Poisson's equations.	CO2	T1:4.3.2,4, 3.3, R2:5.2
9	Study behavior of conductors in an electric field.	CO2	T2: T1:4.6, R2:5.4
10	Understand electric field inside a dielectric material.	CO2	T1:3.5.2-3.5.5 R2:4.3-4.5
11	Discuss on polarization, conductor and dielectric.	CO2	T1:4.7-4.8 R2:6.1
12	Derive dielectric boundary conditions.	CO2,	T1:4.9-4.10, R2:6.2
13	Calculate capacitance of parallel plate and spherical and coaxial capacitors with composite dielectrics	CO2	T1: 5.4-5.7,R2:7.4
14	Define current density, conduction and convection current densities.	CO2	T1:5.8 R2:7.3
15	Define current density, conduction and convection current densities.	CO2	T1:5.8 R2:7.3
16	Calculation of Electric field intensity due to line and surface charges.	CO3	TT1:6.1-6.5. R2:7.7-7.8
17	Derive the work done in moving a point charge in an electrostatic field.	CO3	T1:6.2 R2:6.3 R2:7.3
18	Introduction to static magnetic fields.	CO3	T1:6.3-6.4 R2:7.8
19	State Biot-Savart's law and magnetic field intensity	CO3	T1:7.5-7.7, R2:8.6
20	Find magnetic field for square and solenoid current carrying wire.	CO4	T1:7.8-7.9, R2:8.6-8.7

21	Relation between magnetic flux, magnetic flux density and magnetic field intensity.	CO3	T1:8.2, R2:7.12-7.13
22	Deduce Maxwell's second equation, div (B)=0.	CO3	T1:8.3-8.4, R2:9.4-9.5
23	State point form of Ampere's circuital law	CO3	T1:8.3-8.8 R2:9.4-9.5
24	Deduce Maxwell's third equation, Curl (H)=Jc	CO3	T1:9.2,9.4 R2:9.1
25	Estimate field due to a circular loop, rectangular and square loops.	CO3	T1:4.1-4.5, R2:4.1,5.1
26	Expression for force due to Moving charges in a magnetic field, Lorentz force equation, magnetic dipole.	CO3	T1:4.3.2,4, 3.3, R2:5.2
27	Define vector magnetic potential and its properties.	CO4	T2: T1:4.6, R2:5.4
28	Explain Poisson's equations, self and mutual inductance.	CO4	T1:3.5.2-3.5.5 R2:4.3-4.5
29	Derive Neumann's formula, determination of self inductance of a solenoid, toroid.	CO4	T1:4.7-4.8 R2:6.1
30	State Faraday's laws of electromagnetic induction.	CO5	T1:4.9-4.10, R2:6.2
31	Deduce integral and point forms.	CO5	T1: 5.4-5.7,R2:7.4
32	Derive Maxwell's fourth equation..	CO5	T1:5.8 R2:7.3
33	Derive , statically and dynamically induced emf.	CO5	T1:5.8 R2:7.3
34	Modification of Maxwell's equations for time varying fields.	CO5	TT1:6.1-6.5. R2:7.7-7.8
35	Define displacement current.	CO 5	T1:6.2 R2:6.3 R2:7.3
36	Analysis of wave equation in phasor form	CO5	T1:6.3-6.4 R2:7.8

37	Behavior of plane waves in homogeneous material.	CO5	T1:7.5-7.7, R2:8.6
38	Explain wave equation in conductors and dielectrics.	CO5	T1:7.8-7.9, R2:8.6-8.7
39	Deducing wave equation in conductors and dielectrics.	CO5	T1:8.2, R2:7.12-7.13
40	State skin effect and derive pointing theorem	CO5	T1:8.3-8.4, R2:9.4-9.5
PROBLEM SOLVING/ CASE STUDIES			
1	Vector Algebra	CO1	T1:3.5.2-3.5.5 R2:4.3-4.5
2	Problem on co ordinate conversion	CO1	T1:3.5.2-3.5.5 R2:4.3-4.5
3	Problem on application of coulomb's law	CO1	T1:3.5.2-3.5.5 R2:4.3-4.5
4	Problems on Field intensity calculation	CO1	T1:3.5.2-3.5.5 R2:4.3-4.5
5	Problems on Electrical potential calculation	CO1	T1:4.1-4.5, R2:4.1,5.1
6	Deduce on Laplace and Poisson's Equation	CO1	T1:4.3.2,4, 3.3, R2:5.2
7	Deduce the dipole moment and torque	CO2	T2: T1:4.6, R2:5.4
8	Calculation of capacitance	CO2	T1:3.5.2-3.5.5 R2:4.3-4.5
9	Using Bio-Savart's law find the expression for magnetic field intensity inside a long solenoid carrying current I.	CO2	T1:4.7-4.8 R2:6.1
10	Calculation of energy stored in capacitance	CO2	T1:4.9-4.10, R2:6.2

11	Ampere circuital law for infinitely long current carrying conductor and infinite sheet	CO3	T1: 5.4-5.7,R2:7.4
12	Problems on force calculation of current carrying conductor	CO3	T1:5.8 R2:7.3
13	Problem on self and mutual inductance calculation	CO4	T1:4.204.21, R2:4.5
14	Problems on magnetic dipole moment calculation	CO4	TT1:6.1-6.5. R2:7.7-7.8
15	Problems on emf calculation of time varying field	CO5	T1:6.2 R2:6.3 R2:7.3
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Co ordinate Point charge, unit vector, field intensity, permittivity of Medium, charge distribution	CO1	T1:1.5-1.7, R2:1.1-1.6
2	Electric Dipole, electric dipole moment, potential and toque due to electric dipole.	CO2	T1:2.1-2.8 R2:3.6-8.7
3	Magnetostatics. Magnetic field, magnetic field intensity permeability of core intensity of magnetization.	CO3	T1:4.5-4.10, R2:3.12-3.13
4	magnetic dipole. magnetic dipole moment. torque due to magnetic dipole.	CO4	T1:6.1-6.5. R2:7.7-7.8
5	Dynamically and statistically induced induced emf., time varying field, total current density, displacement and conduction current density. types of emf induced in coil.	CO5	T1:8.3-8.4, R2:9.4-9.5
DISCUSSION OF QUESTION BANK			
1	Module I	CO 1	R4:2.1
2	Module II	CO 2	T4:7.3
3	Module III	CO 3	R4:5.1
4	Module IV	CO 4	T1:7.5
5	Module V	CO 5	T1: 4.1

Signature of Course Coordinator **HOD,EEE**

Dr. Sayanti Chatterjee, Associate Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF(s)
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences **(Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations **(Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions	**10**

	5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**

PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project.	**12**

	6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	
PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change **(Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**

PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer. 1. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electronics and Communication Engineering**				
Course Title	**Electronic Devices and Circuits**				
Course Code	AEC001				
Program	B.Tech				
Semester	III				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. B Naresh, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS006	I	Engineering Physics
B.Tech	AEE002	II	Electriucal Circuits

II COURSE OVERVIEW:

The course provides the constructional features and principle of operation of the basic semiconductor devices such as diodes, bipolar and unipolar transistors. It intended to provide the different biasing configurations of the semiconductor devices to provide temperature stability. Analytical skills to configure semiconductor devices for the applications - rectifiers, clippers, voltage regulators, clampers and amplifiers.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electronic Devices and Circuits	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
50%	Understand
33%	Apply
17%	Analyze
0%	Evaluate
0%	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc.

VI COURSE OBJECTIVES:

The students will try to learn:

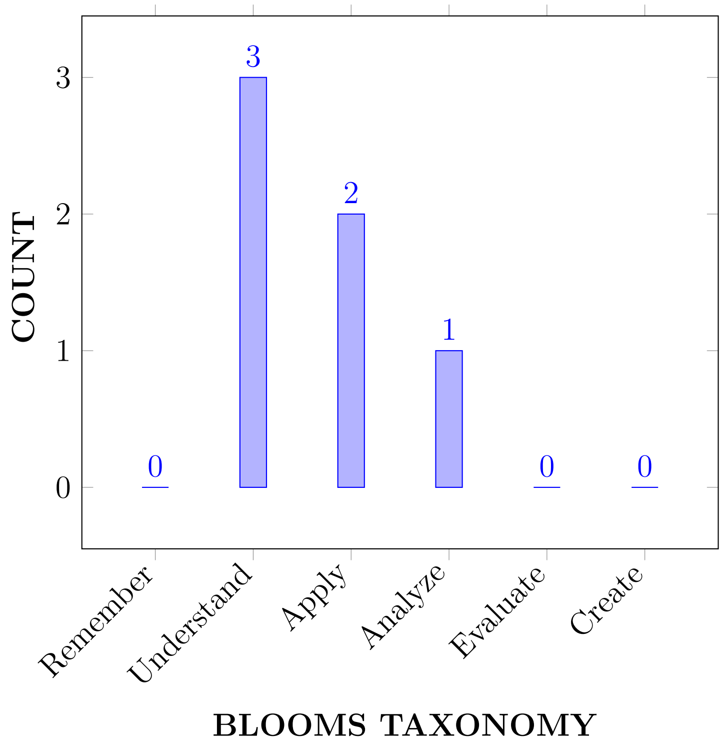
I	the operational principles, characteristics of semiconductor devices and circuits for rectification, amplification, conditioning and voltage regularization of signals.
II	The analytical skills needed to model analog and digital integrated circuits (IC) at discrete and micro circuit level.
III	The foundations of basic electronic circuits necessary for building complex electronic hardware.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Illustrate** the characteristics of semiconductor devices for determining the device parameters such as resistances, current gain and voltage gain.	Understand
CO 2	**Apply** the pn junction characteristics for the diode applications such as switch and rectifiers.	Apply
CO 3	**Examine** DC and AC load line analysis of BJT and FET amplifiers for optimal operating level regardless of input, load placed on the device.	Analyze
CO 4	**Extend** the biasing techniques for bipolar and uni-polar transistor amplifier circuits considering stability condition for establishing a proper operating point.	Understand
CO 5	**Utilize** low frequency model for estimation of the characteristic parameters of BJT, FET amplifier circuits.	Apply
CO 6	**Demonstrate** the working principle of special purpose semiconductor diodes and transistors for triggering and voltage regulation applications.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/CIE/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	SEE/CIE/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	SEE/CIE/AAT
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	SEE/CIE/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	**Build** Embedded Software and Digital Circuit Development platform for Robotics, Embedded Systems and Signal Processing Applications.	2	AAT

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 2	✓	✓	✓	-	-	-	-	-	-	✓	-	-	✓	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 4	✓	✓	✓	-	-	-	-	-	-	✓	-	-	-	-	-
CO 5	✓	✓	-	-	-	-	-	-	-	✓	-	-		-	-
CO 6	✓	-	-	-	-	-	-	-	-	✓	-	-	-	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Illustrate the volt-ampere characteristics **(knowledge)** of semiconductor devices to derive **mathematical model** for diode current, static and dynamic resistance by applying the principles of **mathematics** and **science for solving complex engineering problems.**	2
	PO 2	Understand the given **problem statement** and **formulate** the static and dynamic resistance from the volt-ampere characteristics of the semiconductor devices using **principles of mathematics and engineering science**	3
	PO 10	**Communication:** Communicate effectively on **complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and **write effective reports** and design documentation, make effective presentations, and give and receive clear instructions	2
CO 2	PO 1	Apply **(knowledge)** the pn junction characteristics for the diode applications of diode as switch and rectifiers by **analyzing complex engineering problems** using the principles of **mathematics, engineering science**	2
	PO 2	Understand the given the diode application **problem statement** and finding the **solution implementation** of rectifier circuits by **analyzing complex engineering problems**	4
	PO 3	Design solutions for **complex engineering problems** and **design system components** of **diode applications** that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations.	5
	PO 10	**Communication:** Communicate effectively on **complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and **write effective reports** and design documentation, make effective presentations, and give and receive clear instructions	2
	PSO 1	Formulate and Evaluate the rectifier circuit applications in the field of Intelligent Embedded and Semiconductor technologies	1
CO 3	PO 1	Explain (Understand) DC and AC load line analysis of different amplifiers for optimal operating level by applying **mathematics, science engineering for complex engineering problems.**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Understand the given **problem statement** for DC and AC load line analysis using **complex problem analysis by the principles of mathematics and engineering sciences.**	4
	PO 10	**Communication:** Communicate effectively on **complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and **write effective reports** and design documentation, make effective presentations, and give and receive clear instructions	2
CO 4	PO 1	Design (knowledge) the various biasing techniques for BJT, JFET and MOSFETs amplifier circuits for stable operation by applying **mathematics, science and engineering fundamentals for complex engineering problems.**	3
	PO 2	Understand the **problem statement** of biasing techniques for BJT, JFET and MOSFETs amplifier and formulate a proper operating point in **complex problem analysis using mathematics.**	4
	PO 3	Design solutions for **complex engineering problems** and **design system components** of **BJT and FET amplifiers** that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations.	4
	PO 10	**Communication:** Communicate effectively on **complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and **write effective reports** and design documentation, make effective presentations, and give and receive clear instructions	2
CO 5	PO 1	Estimate (Knowledge) the characteristic parameters of BJT, FET amplifier circuits for **solving complex engineering problems** using low frequency model by applying **mathematics, science and engineering fundamentals.**	3
	PO 2	Analyze small signal analysis **problem statements** of BJT, FET amplifier circuits using **mathematics principles.**	4
	PO 10	**Communication:** Communicate effectively on **complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and **write effective reports** and design documentation, make effective presentations, and give and receive clear instructions	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	PO 1	Demonstrate (Understand) the working principle (knowledge) of special purpose semiconductor devices and transistors like Zener diode, Tunnel diode, SCR, UJT and Photo Diode for applications like triggering and voltage regulation by applying **science for engineering problems.**	1
	PO 10	**Communication:** Communicate effectively on **complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and **write effective reports** and design documentation, make effective presentations, and give and receive clear instructions	2

*__Note__: Refer appendix-I for key competencies

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	2	3	-	-	-	-	-	-	-	2	-	-	-	-	-
CO 2	2	4	5	-	-	-	-	-	-	2	-	-	1	-	-
CO 3	2	4	-	-	-	-	-	-	-	2	-	-	-	-	-
CO 4	3	4	4	-	-	-	-	-	-	2	-	-	-	-	-
CO 5	3	4	-	-	-	-	-	-	-	2	-	-	-		-
CO 6	1	-	-	-	-	-	-	-	-	2	-	-	-		-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	30.0	-	-	-	-	-	-	-	40	-	-	-	-	-
CO 2	66.7	40.0	50.0	-	-	-	-	-	-	40	-	-	50	-	-
CO 3	66.7	40.0	-	-	-	-	-	-	-	40	-	-	-	-	-
CO 4	100	40.0	40.0	-	-	-	-	-	-	40	-	-	-	-	-
CO 5	100	40.0	-	-	-	-	-	-	-	40	-	-	-		-
CO 6	33.3	-	-	-	-	-	-	-	-	40	-	-	-		-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 -$5 < C \leq 40\%$ – Low/ Slight
2 - $40\ \% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 2	3	2	2	-	-	-	-	-	-	1	-	-	2	-	-
CO 3	3	2	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 4	3	2	2	-	-	-	-	-	-	1	-	-	-	-	-
CO 5	3	2	-	-	-	-	-	-	-	1	-	-	-		-
CO 6	1	-	-	-	-	-	-	-	-	1	-	-	-		-
TOTAL	**16**	**9**	**4**	**-**	**-**	**-**	**-**	**-**	**-**	**6**	**-**	**-**	**2**	**-**	**-**
AVERAGE	**2.7**	**1.8**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**2**	**-**	**-**

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Quiz	✓	Tech-Talk	-	Certification	-
Term Paper	-	Seminars	-	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	-	Open Ended Experiments	-
Micro projects	-				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts	-	-

XVIII SYLLABUS:

MODULE I	**SEMICONDUCTOR DIODES**
	pn junction diode: Qualitative theory of pn junction, pn junction as a diode, diode Equation, Volt-Ampere characteristics, temperature dependence of V-I characteristic, ideal versus practical – resistance levels (static and dynamic), transition and diffusion capacitances, diode equivalent circuits, load line analysis, breakdown mechanisms in semiconductor diodes, Zener diode characteristics, Zener diode as a voltage regulator.
MODULE II	**SPECIAL ELECTRONIC DEVICES AND CIRCUITS**
	Special purpose electronic devices: Principles of operation and characteristics of Silicon controlled rectifier, tunnel diode, varavtor diode, Photo diode; Half wave rectifier, Full wave rectifier, general filter considerations, Harmonic components in a rectifier Circuit, Inductor filters, Capacitor filters, L-Section filters,multiplt of L-C section , RC filter, Comparison of filters.
MODULE III	**TRANSISTORS**
	Bias Stability, Fixed Bias, Collector to base bias, Self-Bias, Bias compensation using diodes and transistors. **Analysis and Design of Small Signal Low Frequency BJT Amplifiers:** Analysis of CE, CC, CB amplifiers and CE amplifier with emitter resistance, low frequency response of BJT amplifiers, effect of coupling and bypass capacitors on CE amplifier.
MODULE IV	**BIASING AND COMPENSATION TECHNIQUES**
	Biasing and Compensation techniques: Operating Point, The DC and AC Load lines, types of biasing circuits, bias Stability, stabilization factors, stabilization against variations in VBE , bias compensation techniques, thermal runaway, thermal stability, biasing the FET and MOSFET.
MODULE V	**BJT AND FET AMPLIFIERS**
	BJT small signal analysis, BJT hybrid model, determination of h-parameters from transistor characteristics, transistor amplifier, analysis using h-parameters; FET small signal model, FET as common source amplifier, , FET as common drain amplifier, , FET as common gate amplifier, generalized FET amplifier.

TEXTBOOKS

1. S Salivahanan, N Suresh Kumar " Electronic Devices and Circuits", 2nd Edition, 2018, McGraw Hill Education.
2. J. Millman and Christos C. Halkias, "Integrated Electronics", International Student Edition , 2008, Tata McGraw Hill Publications.
3. David A. Bell, "Electronic Devices and Circuits", 5th Edition, Oxford University Press.

REFERENCE BOOKS:

1. R.L. Boylestad and Louis Nashelsky, “Electronic Devices and Circuits”, 9th Edition, 2006, PEI/PHI.
2. B.P.Singh, Rekha Singh, “Electronic Devices and Circuits”, 2nd Edition, 2013, Pearson Publisher.
3. K. Lal Kishore, “Electronic Devices and Circuits”, 2nd Edition, 2005,BS Publisher.
4. Anil K. Maini and Varsha Agarwal, “Electronic Devices and Circuits”, 1stEdition, 2009, Wiley India Pvt. Ltd.

COURSE WEB PAGE:

https://www.iare.ac.in/?q=courses/electronics-and-communication-engineering-autonomous/electronic-devices-and-circuits

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		https://www.iare.ac.in/?q=courses/electron\ics-and-co\mmunicati\on-enginee\ring-auton\omouselec\tronic-de\vices-and-\circuits
CONTENT DELIVERY (THEORY)			
2	Qualitative theory of pn junction	CO 1	T1: 2.2
3	pn junction as a diode, diode current equation	CO 1	T1: 2.2, 2.4
5	Volt-Ampere characteristics, temperature dependence of V-I characteristic	CO 1	T1: 2.2
6	Diode resistances, equivalent circuit	CO 1	T1: 2.6
8	Diffusion and Transition Capacitances, Load line analysis	CO 1	T1: 2.7
9	Breakdown mechanisms in semiconductor diodes	CO 1	T1: 2.10
10	Zener diode characteristics	CO 6	T1: 2.9
11	Zener diode as a voltage regulator.	CO 6	T1: 2.11
13	SCR	CO 6	T1: 2.16
14	Tunnel diode	CO 6	T1: 2.12
15	varavtor diode, Photo diode	CO 6	T1: 2.17
16	Half wave rectifier	CO 2	T1: 3.2
18	Full wave rectifier	CO 2	T1: 3.2

20	Bridge rectifier, harmonic components in a rectifier circuit	CO 2	T1: 3.2, 3.3
21	Rectifiers with capacitive filter	CO 2	T1: 3.6
22	L-Section filters, multiple of L-C section	CO 2	T1: 3.7
23	RC filter, Comparison of filters.	CO 2	T1: 3.9
24	Principle of operation of BJT	CO 1	T1: 4.2
25	Common emitter configuration with characteristics	CO 1	T1: 4.4
26	Common base configuration with characteristics	CO 1	T1: 4.4
27	Common collector configuration with characteristics	CO 1	T1: 4.4
28	Transistor current components and relation among current gains	CO 1	T1: 4.3
30	Field effect transistors: Types of FET, FET construction, symbol, principle of operation	CO 1	T1: 4.12,4.13
31	V-I characteristics, FET parameters, FET as voltage variable resistor	CO 1	T1: 4.14
32	comparison of BJT and FET	CO 1	T1: 4.2
33	MOSFET construction and operation	CO 1	T1: 4.15
34	Uni Junction Transistor: Symbol, Principle of operation, UJT Characteristics, UJT applications.	CO 6	T1: 2.19
35	Operating point, DC & AC load lines	CO 3	T1: 5.3
37	Transistor biasing and stabilization	CO 4	T1: 5.4
38	Fixed Bias, Collector to Base bias	CO 4	T1: 5.4
39	Self-Bias	CO 4	T1: 5.4
40	Bias Compensation using Diodes and Transistors	CO 4	T1: 5.6
44	Thermal Runaway, Thermal Stability	CO 4	T1: 5.7, 5.8
45	Transistor Hybrid parameter model	CO 5	T1: 6.3
46	Exact and approximate analysis of transistor amplifier using low frequency model	CO 5	T1: 6.6, 6.8
47	Analysis of CE amplifier with emitter resistance using low frequency model	CO 5	T1: 6.9
48	Effect of coupling and bypass capacitors on CE Amplifier	CO 5	R4:7.4
49	Analysis of generalized JFET Amplifier	CO 5	T1: 6.15
53	Analysis of CS JFET Amplifier	CO 5	T1:6.16
54	Analysis of CD and CG JFET Amplifier	CO 5	T1:6.17, 6.18
PROBLEM SOLVING/ CASE STUDIES			
4	Diode current equation	CO 1	T1:2.4
7	Diode resistances	CO 1	T1:2.6
12	Zener diode regulator	CO 6	T1:2.11
17	Half wave Rectifier parameters estimation	CO 2	T1:3.2
19	Full wave Rectifier parameters estimation	CO 2	T1:3.2
29	Current gain of transistor configuration	CO 1	T1:4.3
36	Load line analysis of BJT	CO 3	T1:5.3
39	Transistor fixed biasing	CO 4	T1:5.4
40	Transistor collector to base biasing	CO 4	T1:5.4

42	Transistor self-biasing	CO 4	T1:5.4
49	CE Transistor amplifier analysis	CO 5	T1:6.9
50	CB Transistor amplifier analysis	CO 5	T1:6.11
51	CC Transistor amplifier analysis	CO 5	T1:6.10
55	CS Amplifier analysis	CO 5	T1:6.16
56	CD Amplifier analysis	CO 5	T1: 6.17
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Semiconductor diodes	CO 1	T1: 2.2 – 2.9
58	Special electronic devices and rectifiers	CO 2, CO 6	T1: 2.16, 3.2 -3.9
59	Transistors	CO 1, CO 3, CO 5	T1:4.2-4.15
60	Biasing and compensation techniques	CO 4	T1:5.4-5.8
61	BJT and FET amplifiers	CO 5	T1:6.3 -6.18
DISCUSSION OF QUESTION BANK			
62	Semiconductor diodes	CO 1	T1: 2.2 – 2.9
63	Special electronic devices and rectifiers	CO 2, CO 6	T1: 2.16, 3.2 -3.9
64	Transistors	CO 1, CO 3, CO 5	T1:4.2-4.15
65	Biasing and compensation techniques	CO 4	T1:5.4-5.8
66	BJT and FET amplifiers	CO 5	T1:6.3 -6.18

Signature of Course Coordinator **HOD, ECE**
Mr. B Naresh, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**

PO 4.	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions **(Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice **(The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**

PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**

PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**
PO12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRON ICS ENGINEERING
COURSE DESCRIPTION

Course Title	**DC Machines Laboratory**				
Course Code	AEE104				
Program	B.Tech				
Semester	III	EEE			
Course Type	Core				
Regulation	R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Mr. A Sathish kumar, Assistant Professor				

I COURSE OVERVIEW:

This laboratory course is to meet the requirements of practical work meant for basic operation, analysis and design of electrical machines. It provides hands-on experience by examining the electrical and mechanical characteristics of various DC machines. Analyze the characteristics of DC machines and separate the various losses in electrical machines by conducting different tests..

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE002	II	Electrical Circuits Lab

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electrical Machines Laboratory - I Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner,

both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 % hline 20 %	Objective Analysis	- -
20 %	Design	-
20 %	Conclusion	-
20 %	Viva	-

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

I	The elementary experimental and modelling skills for handling problems with electrical machines in the industries and domestic applications to excel in professional career.
II	The operation of DC Machines and its role in power transmission and distribution.
III	The intuitive knowledge needed to test and analyse the performance leading to design of electric machines by conducting various tests and calculate the performance parameters.

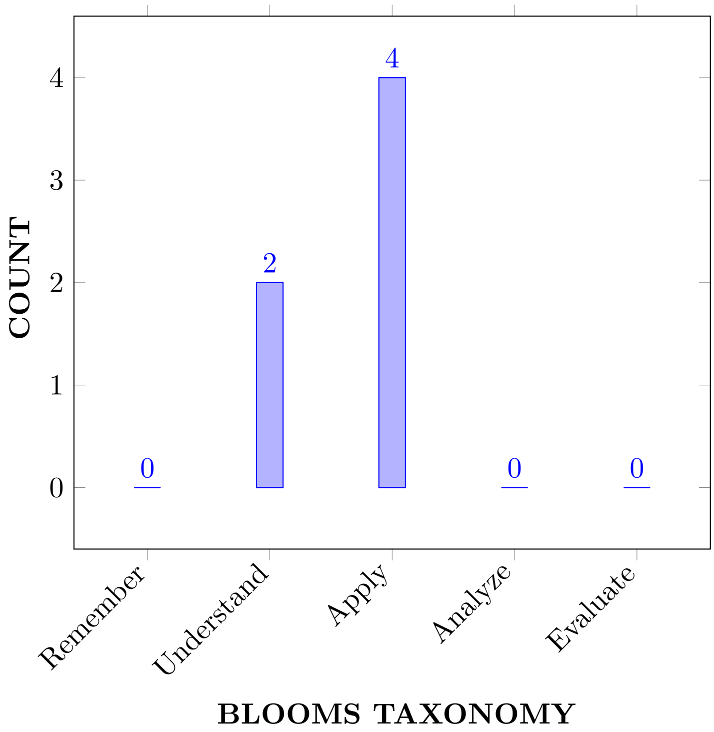
VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Formulate** and then analyze the working of any electrical machine to using mathematical model under loaded and unloaded conditions. .	Understand

CO 2	**Interpret** the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions.	Apply
CO 3	**Apply** magnetization characteristics of dc shunt generator for necessary to do mechanical work in a proper way.	Apply
CO 4	**Demonstrate** the starting and speed control of various DC motors for necessary to do mechanical work in a proper way of DC motors.	Understand
CO 5	**Estimate** the core losses of DC shunt machines for dividing the set losses.	Apply
CO 6	**Apply** digital simulation techniques for speed control methods and load test of DC motors.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations

Program Outcomes	
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	Lab Exercises
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3	Lab Exercises

PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	Lab Exercises
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	Lab Exercises
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	3	Lab Exercises
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Lab Exercises
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Lab Exercises
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	2	Lab Exercises
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	2	Lab Exercises
PSO 3	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Observe the working of electrical machines using mathematical model under loaded and unloaded conditions using **principles of mathematics and engineering science**	2
	PO 2	Understand the working of electrical machines using mathematical model under loaded and unloaded conditons **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the given power electronic components voltage current characteristics **for design solutions of complex engineering problems**	6
	PO 4	Understand the working of electrical machines using mathematical model under loaded and unloaded conditions **with analysis and interpretation of data**	6
	PO 6	Illustrate the working of electrical machines using mathematical model under loaded and unloaded conditions **for safety issues in professional engineering practice**	4
	PO 8	Understand the working of electrical machines using mathematical model under loaded and unloaded conditions **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte working of electrical machines using mathematical model under loaded and unloaded conditions **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret working of electrical machines using mathematical model under loaded and unloaded conditions **with communication of complex engineering practices**	3
	PO 12	Understand the working of electrical machines using mathematical model under loaded and unloaded conditions **in life long learning in technological change**	6
	PSO 1	Demonstrate the working of electrical machines using mathematical model under loaded and unloaded conditions **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the working of electrical machines using mathematical model under loaded and unloaded conditions **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the given working of electrical machines using mathematical model under loaded and unloaded conditions **in automation process using PLC and process controllers**	4

CO 2	PO 1	Observe the the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions using **principles of mathematics and engineering sciences**	2
	PO 2	Understand the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions with**problem statement by analyzing complex engineering problems.**	6
	PO 3	Develop the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **for design solutions of complex engineering problems**	6
	PO 4	Understand thethe load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **with analysis and interpretation of data**	6
	PO 6	Illustrate the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **for safety issues in professional engineering practice**	4
	PO 8	Understand the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **with communication of complex engineering practices**	3
	PO 12	Understand the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **in life long learning in technological change**	6
	PSO 1	Demonstrate the the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **in automation process using PLC and process controllers**	4

CO 3	PO 1	Observe magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed using **principles of mathematics and engineering science**	2
	PO 2	Understand magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **for design solutions of complex engineering problems**	6
	PO 4	Understand magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **with analysis and interpretation of data**	6
	PO 5	Understand magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **modelling using IT tools such as MATLAB**	6
	PO 6	Illustrate magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **for safety issues in professional engineering practice**	4
	PO 8	Understand magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **with communication of complex engineering practices**	3
	PO 12	Understand magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **in life long learning in technological change**	6
	PSO 1	Demonstrate magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed**in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **in automation process using PLC and process controllers**	4

CO 4	PO 1	Observe the starting and speed control of various DC motors for necessary to do mechanical work in a proper way using **principles of mathematics and engineering science**	2
	PO 2	Understand the starting and speed control of various DC motors for necessary to do mechanical work in a proper way **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **for design solutions of complex engineering problems**	6
	PO 4	Understand the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **with analysis and interpretation of data**	6
	PO 5	Understand the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **modelling using IT tools such as MATLAB**	6
	PO 6	Illustrate the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **for safety issues in professional engineering practice**	4
	PO 8	Understand the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **with communication of complex engineering practices**	3
	PO 12	Understand the starting and speed control of various DC motors for necessary to do mechanical work in a proper waysn **in life long learning in technological change**	6
	PSO 1	Demonstrate the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **in automation process using PLC and process controllers**	4

CO 5	PO 1	Observe the core losses of DC shunt machines for dividing the set losses using **principles of mathematics and engineering science**	2
	PO 2	Understand the core losses of DC shunt machines for dividing the set losses **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the core losses of DC shunt machines for dividing the set losses **for design solutions of complex engineering problems**	6
	PO 4	Understand the core losses of DC shunt machines for dividing the set losses **with analysis and interpretation of data**	6
	PO 6	Illustrate the core losses of DC shunt machines for dividing the set losses**for safety issues in professional engineering practice**	4
	PO 8	Understand the core losses of DC shunt machines for dividing the set losses **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the core losses of DC shunt machines for dividing the set losses **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the core losses of DC shunt machines for dividing the set losses **with communication of complex engineering practices**	3
	PO 12	Understand the core losses of DC shunt machines for dividing the set losses **in life long learning in technological change**	6
	PSO 1	Demonstrate the core losses of DC shunt machines for dividing the set losses **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the core losses of DC shunt machines for dividing the set losses **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the core losses of DC shunt machines for dividing the set losses **in automation process using PLC and process controllers**	4
CO 6	PO 1	Observe digital simulation techniques for speed control methods and load test of DC motors using **principles of mathematics and engineering science**	2
	PO 2	Understand digital simulation techniques for speed control methods and load test of DC motors **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate digital simulation techniques for speed control methods and load test of DC motors **for design solutions of complex engineering problems**	6

	PO 4	Understand digital simulation techniques for speed control methods and load test of DC motors **with analysis and interpretation of data**	6
	PO 5	Understand digital simulation techniques for speed control methods and load test of DC motors **modelling using IT tools such as MATLAB**	6
	PO 6	Illustrate digital simulation techniques for speed control methods and load test of DC motors **for safety issues in professional engineering practice**	4
	PO 8	Understand digital simulation techniques for speed control methods and load test of DC motors **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte digital simulation techniques for speed control methods and load test of DC motors **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret digital simulation techniques for speed control methods and load test of DC motors **with communication of complex engineering practices**	3
	PO 12	Understand digital simulation techniques for speed control methods and load test of DC motors **in life long learning in technological change**	6
	PSO 1	Demonstrate digital simulation techniques for speed control methods and load test of DC motors **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand digital simulation techniques for speed control methods and load test of DC motors **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate digital simulation techniques for speed control methods and load test of DC motors **in automation process using PLC and process controllers**	4

XII MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	3	3	-	2	-	3	2	2	-	2	2	3	3
CO 2	3	3	3	3	-	2	-	3	2	2	-	2	2	3	3
CO 3	3	3	3	3	3	2	-	3	2	2	-	2	2	3	3
CO 4	3	3	3	3	3	2	-	3	2	2	-	2	2	3	3
CO 5	3	3	3	3	-	2	-	3	2	2	-	2	2	3	3
CO 6	3	3	3	3	3	2	-	3	2	2	-	2	2	3	3

XIII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams		SEE Exams		Seminars	-
Laboratory Practices		Student Viva		Certification	-
Assignments	-				

XIV ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XV SYLLABUS:

WEEK I	**OPEN CIRCUIT CHARACTERISTICS OF DC SHUNT GENERATOR**
	Magnetization characteristics of DC shunt generator.
WEEK II	**LOAD TEST ON DC SHUNT GENERATOR**
	Determination of efficiency by load test in DC shunt generator
WEEK III	**LOAD TEST ON DC SERIES GENERATOR**
	Determination of efficiency by load test on DC series generator.
WEEK IV	**LOAD TEST ON DC COMPOUND GENERATOR**
	Determination of efficiency by load test on DC compound generator
WEEK V	**HOPKINSON'S TEST**
	Study the performance characteristics of two identical DC shunts machines.
WEEK VI	**FIELD'S TEST**
	Study the performance characteristics of two identical DC series machines.
WEEK VII	**SWINBURNE'S TEST AND SPEED CONTROL OF DC SHUNT MOTOR**
	Predetermine the efficiency and study the characteristics of DC shunt machine with different speed control techniques..
WEEK VIII	**BRAKE TEST ON DC COMPOUND MOTOR**
	Study the performance characteristics of DC compound motor.
WEEK IX	**BRAKE TEST ON DC SHUNT MOTOR**
	Study the performance characteristics of DC shunt motor by brake test.
WEEK X	**RETARDATION TEST**
	Study the performance characteristics by using retardation test on DC shunt motor
WEEK XI	**SEPARATION OF LOSSES IN DC SHUNT MOTOR**
	Study the method used for separation of losses in DC shunt motor

WEEK XII	**MAGNETIZATION CHARACTERISTICS OF DC SHUNT GENERATOR**
	Study the magnetization characteristics of DC shunt generator using digital simulation
WEEK XIII	**LOAD TEST ON DC SHUNT GENERATOR USING DIGITAL SIMULATION**
	Perform the load test on DC shunt generator using digital simulation
WEEK XIV	**SPEED CONTROL OF DC SHUNT MOTOR USING DIGITAL SIMULATION**
	Verify the speed control techniques of DC motor using digital simulation

TEXTBOOKS

1. J B Guptha "Theory and performance of Electrical machiines", S.K.Kataria and Sons Publishers 14th Edition, 2009

2. M G Say, E O Taylor, "Direct Current Machines", Longman Higher Education, 1st Edition,1985

REFERENCE BOOKS:

1. P S Bimbhra, R.P., —Electrical Machinery, Khanna Publishers, New Delhi 2011

2. I J Nagrath and D P Kothari., Electric Machines, McGraw Hill Education Co. Ltd., 2010.

3. A E Fitzgerald and C Kingsley, "Electric Machinery", New York, McGraw Hill Education, 1st Edition, 2013.

XVI COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Magnetization characteristics of DC shunt generator.	CO 3	R1: 1.2
2	Determination of efficiency by load test in DC shunt generator.	CO 1	R2: 3.5
3	Determination of efficiency by load test on DC series generator	CO 1	R1: 3.4
4	Determination of efficiency by load test on DC compound generator	CO 1	R1: 2.2
5	Study the performance characteristics of two identical DC shunts machines.	CO 1	R1: 2.4
6	Study the performance characteristics of two identical DC series machines.	CO 1	R3: 4.5
7	Predetermine the efficiency and study the characteristics of DC shunt machine with different speed control techniques.	CO 4	R3: 4.6
8	Study the performance characteristics of DC compound motor	CO 1	R2: 5.1
9	Study the performance characteristics of DC shunt motor by brake test.	CO 1	R2: 5.2
10	Study the performance characteristics by using retardation test on DC shunt motor.	CO 1	R1: 7.1

11	Study the method used for separation of losses in DC shunt motor.	CO 5	R1:7.2
12	Study the magnetization characteristics of DC shunt generator using digital simulation	CO 6	R1:7.3
13	Perform the load test on DC shunt generator using digital simulation	CO 6	R2: 7.1
13	Verify the speed control techniques of DC motor using digital simulation.	CO 6	R3: 8.1

XVII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Twin vortex formation:** Design of brushless DC motor for Hybrid Electrical Vehicles.
2	**Open channel:** Design of parallel operation of DC generators for load sharing capabilities .
3	**Capillary action:** Modelling of direct drive motors for performance improvement by design and control.
4	**Buoyancy** Design of three point starter using digital simulation.
5	**Flow through pipes:** Design of permanent magnet DC Motor for Hybrid Electrical Vehicles

Signature of Course Coordinator **HOD,EEE**
Mr.A Sathish Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTION

Course Title	**ELECTRICAL ENGINEERING SIMULATION LABORATORY**				
Course Code	AEE105				
Program	B.Tech				
Semester	III	EEE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Ms.S Swathi, Assistant Professor				

I COURSE OVERVIEW:

The Electrical Engineering Simulation Laboratory is designed to give hands-on experience on virtual instrumentation through digital simulation techniques. The emphasis of this course is laid on the basic analysis of circuits which includes three phase circuits, transient analysis of DC and AC circuits, network functions, and two port net work parameters, Fourier analysis of AC circuits, design and analysis of filters.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS002	I	Linear Algebra and Ordinary Differential Equations
B.Tech	AHS011	II	Mathematical Transform Techniques
B.Tech	AEE002	II	Electrical Circuits

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electrical Engineering Simulation Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

I	Measure the active and reactive power in a three phase system.
II	Two port network parameters of different electrical circuits.
III	Time varying characteristics of series and parallel circuits using MATLAB.

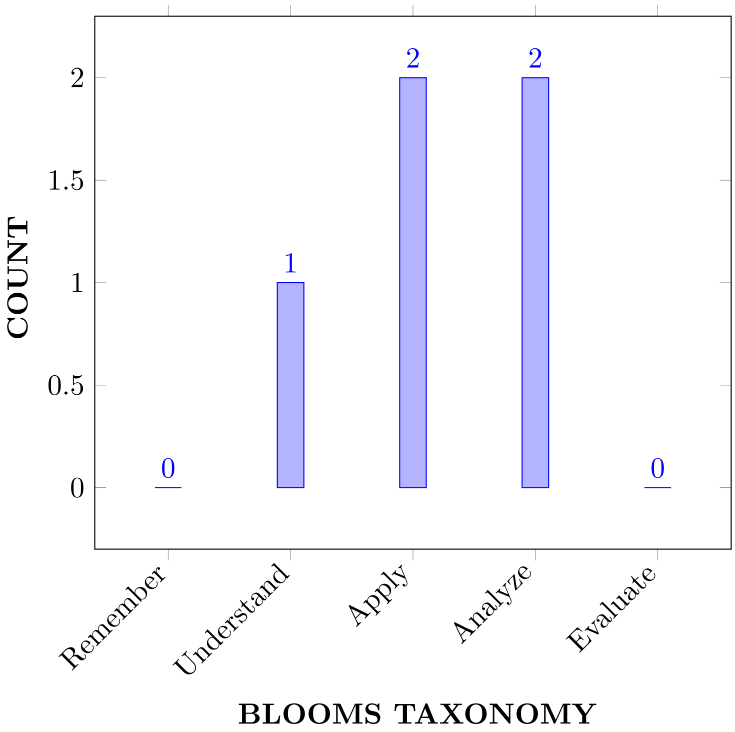
IV	Design the low pass and high pass filters and Analyse the basic circuits, waveforms using Fourier transform, LabVIEW, Visio Software.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Calculate** various parameters of two port network for analyzing different electrical circuits.	Apply
CO 2	**Examine** the transfer function for studying transient response of RL, RC and RLC circuits.	Understand
CO 3	**Analyze** the virtual instrumentation (VI) using control loops, arrays, charts and graphs.	Analyze
CO 4	**Determine** various alternating quantities of single phase and three phase signals.	Apply
CO 5	**Analyze** the basic circuits, rectified waveforms using Fourier transform and Visio Software.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Laboratory experiments, internal and external lab exam
PO 2	**Problem Analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	1	Laboratory experiments, internal and external lab exam
PO 5	**Modern Tool Usage:** Create,select and apply appropriate techniques,resources and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of limitation.	1	Laboratory experiments, internal and external lab exam
PO 8	**Ethics:** Apply ethical principles and commit to professikonal ethics and responsibilties and norms of the engineering practice.	3	Laboratory experiments, internal and external lab exam
PO 9	**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	Laboratory experiments, internal and external lab exam
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	3	Laboratory experiments,internal and external lab exam
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	Laboratory experiments, internal and external lab exam

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	2	Lab Exercises
PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer.	1	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Define a two port networks and procedure to obtain Z, Y parameters with the **knowledge of mathematics, science and engineering fundamentals.**	3
	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice **in calculating the two-port network parameters**	1
	PO 9	Work effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings **in calculating the two-port network parameters**	3
	PO 10	Communicate effectively on complex engineering activities with the engineering community and with society **in calculating the two-port network parameters**	3
	PO 12	The preparation and ability to engage in independent and life-long learning in the broadest context of technological change **in calculating the two-port network parameters**	3
	PSO 1	Obtain the two port network parameters **in the field of electrical system.**	1
CO 2	PO 1	Define the transient response of electrical circuit with the **knowledge of mathematics, science and engineering fundamentals.**	3
	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice **in obtaing the transient response of series and parallel electrical networks**	1

	PO 9	Work effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings **in obtaing the transient response of series and parallel electrical networks**.	3
	PO 10	Communicate effectively on complex engineering activities with the engineering community and with society **in obtaing the transient response ofseries and parallel electrical networks**.	5
	PO 12	The preparation and ability to engage in independent and life-long learning in the broadest context of technological change **in obtaing the transient response of series and parallel electrical networks**.	3
	PSO 1	Obtain the time varying characteristics to know the behavior of series and parallel electrical networks **in the field of electrical system.**	3
CO 3	PO 1	Obtain the virtual instrumentation using control loops, arrays and graphs with the **knowledge of mathematics, science and engineering fundamentals.**	3
	PO 5	Editing and Building a VI, creating a sub VI in virtual instrumentation using control loops, arrays and graphs **helps in simulation for all requited specifications.**	2
	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice **in analyzing VI using control loops, arrays and graphs**	1
	PO 9	Work effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings **in analyzing VI using control loops, arrays and graphs**.	3
	PO 10	Communicate effectively on complex engineering activities with the engineering community and with society **in analyzing VI using control loops, arrays and graphs**.	5
	PO 12	The preparation and ability to engage in independent and life-long learning in the broadest context of technological change **in analyzing VI using control loops, arrays and graphs**.	3
	PSO 1	Analyze the VI using control loops, arrays and graphs **in the field of electrical system.**	3
	PSO 3	**Simulate the electrical system** by building a VI, creating a sub VI in virtual instrumentation using control loops, arrays and graphs.	3
CO 4	PO 1	Determine the various alternating quantities of an AC system with the **knowledge of mathematics and engineering fundamentals.**	3
	PO 2	Determine the three phase AC system active and reactive powers **using basics of mathematics and engineering sciences.**	3

	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice **in determining the various alternating quantities of an AC system**	1
	PO 9	Work effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings **in determining the various alternating quantities of an AC system**.	3
	PO 10	Communicate effectively on complex engineering activities with the engineering community and with society **in determining the various alternating quantities of an AC system**.	3
	PO 12	The preparation and ability to engage in independent and life-long learning in the broadest context of technological change **in determining the various alternating quantities of an AC system**.	3
	PSO 1	Interpret the single and three phase AC system for computing **in the field of electrical system.**	1
CO 5	PO 1	Analysis of basic circuits and square wave, half wave rectified, full wave rectified sine wave using Fourier transforms and Visio software with the **knowledge of mathematics and engineering fundamentals.**	3
.	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice **in analysis of basic circuits and waveforms**	1
	PO 9	Work effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings **in analysis of basic circuits and waveforms**.	3
	PO 10	Communicate effectively on complex engineering activities with the engineering community and with society **in analysis of basic circuits and waveforms**.	3
	PO 12	The preparation and ability to engage in independent and life-long learning in the broadest context of technological change **in analysis of basic circuits and waveforms**.	3
	PSO 1	Analyze the single and three phase AC system for computing its parameters **in the field of electrical system.**	1

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES							PSO	
	PO 1	PO 2	PO 5	PO 8	PO 9	PO10	PO12	PSO1	PSO 3
CO 1	3			1	3	3	3	1	
CO 2	3			1	3	3	3	1	
CO 3	3		1	1	3	3	3	1	1

CO 4	3	1		1	3	3	3	1	
CO 5	3			1	3	3	3	1	

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**MEASUREMENT OF THREE PHASE ACTIVE AND REACTIVE POWER**
	Measurement of three phase active and reactive power for balanced and unbalanced loads.
WEEK II	**LOCUS DIAGRAMS**
	Plot the locus diagram of series RL and RC circuits.
WEEK III	**IMPEDANCE(Z) AND ADMITTANCE(Y) PARAMETERS**
	To calculate and verify ‘Z’ parameters and ‘Y’ parameters of two-port network.
WEEK IV	**TRANSMISSION(ABCD)AND HYBRID(H) PARAMETERS**
	To calculate and verify ‘ABCD’ parameters and ‘H’ parameters of two-port network.
WEEK V	**FOURIER ANALYSIS**
	Fourier analysis of square wave, half wave rectified and full wave rectified sine wave using MATLAB.
WEEK VI	**ELECTRICAL SYMBOLS USING VISIO SOFTWARE**
	Draw the electrical symbols using VISIO software.
WEEK VII	**TRANSIENT RESPONSE OF RL AND RC CIRCUITS USING DIGITAL SIMULATION**
	To study and plot the transient response of series and parallel RL and RC circuits using MATLAB.
WEEK VIII	**TRANSIENT RESPONSE OF RLC CIRCUITS USING DIGITAL SIMULATION**
	To study and plot the transient response of series and parallel RLC circuits using MATLAB.

WEEK IX	**DESIGN OF LOW PASS AND HIGH PASS FILTERS USING DIGITAL SIMULATION**
	Simulation of low pass and high pass filters using digital simulation..
WEEK X	**VIRTUAL INSTRUMENTS (VI) USING LABVIEW**
	Editing and building a VI, creating a sub VI.
WEEK XI	**STRUCTURES USING LABVIEW**
	Using FOR loop, WHILE loop, charts and arrays, graph and analysis VIs.
WEEK XII	**GENERATION OF COMMON WAVE FORMS AND FREQUENCY MEASUREMENT USING LABVIEW**
	AC Signal generation and display of waveform, minimum and maximum values of wave form and modulation and Frequency measurement using Lissajous figures in Lab View.
WEEK XIII	**SINE WAVE GENERATION USING LABVIEW**
	Three phase sine wave generation and display.
WEEK XIV	**FREQUENCY MEASUREMENT USING LISSAJIOUS PATTERN IN LABVIEW**
	Measure the frequency of unknown signal using Lissajious pattern in LAB View

TEXTBOOKS

1. Rudrapratap, "Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers",Oxford University Press, 1st Edition, 1999.

2. Nesimiertugrul, "Labview for electric circuits, machines, drives, and laboratories", prentice hall, 1st Edition, 2002

REFERENCE BOOKS:

1. A Chakrabarti, "Circuit Theory", Dhanpat Rai Publications, 6th Edition, 2006.

2. William Hayt, Jack E Kemmerly S.M. Durbin, "Engineering Circuit Analysis", Tata McGraw Hill, 7th Edition, 2010.

3. K S Suresh Kumar, "Electric Circuit Analysis", Pearson Education, 1st Edition, 2013.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Measurement of three phase active and reactive power for balanced and unbalanced loads.	CO 4	R1: 1.2
2	Plot the locus diagram of series RL and RC circuits.	CO 4	R2: 3.5
3	To calculate and verify 'Z' parameters and 'Y' parameters of two-port network.	CO 1	R1: 3.4
4	To calculate and verify 'ABCD' parameters and 'H' parameters of two-port network.	CO 1	R1: 2.2
5	Fourier analysis of square wave, half wave rectified and full wave rectified sine wave using MATLAB.	CO 5	R1: 2.4
6	Draw the electrical symbols using VISIO software.	CO 5	R3: 4.5

7	To study and plot the transient response of series and parallel RL and RC circuits using MATLAB.	CO 2	R3: 4.6
8	To study and plot the transient response of series and parallel RLC circuits using MATLAB.	CO 2	R2: 5.1
9	Simulation of low pass and high pass filters using digital simulation.	CO 5	R2: 5.2
10	Editing and building a VI, creating a sub VI.	CO 3	R1: 7.1
11	Using FOR loop, WHILE loop, charts and arrays, graph and analysis VIs.	CO 3	R1:7.2
12	AC Signal generation and display of waveform, minimum and maximum values of wave form and modulation and Frequency measurement using Lissajous figures in Lab View.	CO 3	R1:7.3
13	Three phase sine wave generation and display using LAB View.	CO 3	R1:7.2
14	Measure the frequency of unknown signal using Lissajious pattern in LAB View.	CO 3	R1:7.3

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Resonance:** Verification of resonance phenomena for series and parallel circuits.

Signature of Course Coordinator **HOD,EEE**
Ms. S Swathi, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**AC Machines**				
Course Code	AEE007				
Program	B.Tech				
Semester	IV				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. K Devender Reddy				

I COURSE OVERVIEW:

This course deals with the basic theory, construction, operation, performance characteristics and application of electromechanical energy conversion devices such as synchronous and asynchronous machines. It also facilitates the study of the alternating machines which are the major part of industrial drives and agricultural pump sets.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE004	III	DC Machines and Transformers
B.Tech	AEE005	III	Network Analysis
B.Tech	AEE006	III	Electromagnetic Fields

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
AC Machines	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	✓	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could

be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
60%	Understand
40%	Apply
0 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc.

VI COURSE OBJECTIVES:

The students will try to learn:

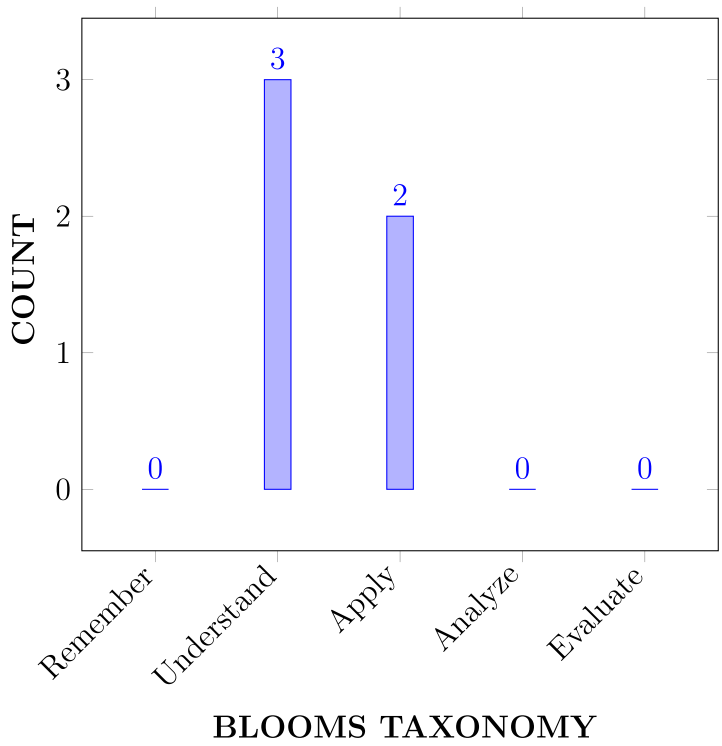
I	The principle of operation and the effect of pulsating, rotating magnetic fields on the working of AC machines
II	The armature winding layouts and concept of armature reaction with phasor diagrams.
III	The staring, speed control methods and equivalent circuit diagram of poly phase and single phase machines.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Demonstrate** various winding factors, spatially displaced armature windings to generate electro motive force in AC machines.	Understand
CO 2	**Illustrate** electromagnetic laws used for the construction and operation of synchronous and asynchronous machines.	Understand
CO 3	**Identify** various control strategies for calculating the performance parameters and voltage regulation of AC machines.	Apply
CO 4	**Demonstrate** the parallel operation of alternators for load sharing under various loading conditions.	Understand
CO 5	**Examine** the behavior of synchronous motor with variable excitation and loadings for calculating armature current, power and power factor	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Program Outcomes	
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE / CIE / AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	SEE / CIE / AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	SEE / CIE / AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	SEE / CIE / AAT
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	1	SEE / CIE / AAT
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	SEE / CIE / AAT
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	SEE / CIE / AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.	2	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	✓	-	-	-	-	-	✓	✓	-	✓	✓	-	-
CO 2	✓	✓	-	-	-	-	-	-	✓	✓	-	✓	✓	-	-
CO 3	✓	✓	✓	✓	-	-	-	-	✓	✓	-	✓	-	-	-
CO 4	✓	✓	-	✓	-	-	-	-	✓	✓	-	✓	✓	-	-
CO 5	✓	✓	✓	-	-	-	-	-	✓	✓	-	✓	-	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Generation of various magnetic fields and different armature windings using the **knowledge of mathematics and engineering sciences**	2
	PO 2	Calculate the induced EMF using winding factors with **first principles of mathematics and engineering sciences**	4
	PO 3	**Demonstrate** spatial displaced windings and winding factors for production of EMF with **design solutions for complex engineering problems**	5
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance winding factors.	5
	PO 10	**Communicate** effectively on **complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and **write effective reports and design documentation**, make effective presentation and give and receive clear instructions.	2
	PO 12	Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the context of employability and higher education	4

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 1	**Understand** various windings and winding factors for **generation** of induced EMF	4
CO 2	PO 1	Demonstrate electromagnetic laws for the operation of AC machines with **engineering sciences**	2
	PO 2	**Understand** the operation and constructional features of synchronous and asynchronous machines using engineering sciences	4
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams to understand constructional features and operation of various types of AC machines.	5
	PO 10	**Communicate** effectively on **complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and **write effective reports and design documentation**, make effective presentation and give and receive clear instructions.	2
	PO 12	Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the context of employability and higher education	4
	PSO 1	**Understand** electromagnetic laws for the operation of electrical machines for power generation and utilization	4
CO 3	PO 1	Calculate performance parameters of AC machines using **mathematics, science and engineering fundamentals**	3
	PO 2	Draw the circle diagram for calculating equivalent circuit parameters using **first principles of mathematics and engineering sciences**	5
	PO 3	calculate equivalent circuit parameters of AC machines using **design solutions for complex engineering problems**	5
	PO 4	Calculate the voltage regulation of alternator using research-based knowledge and research methods including design of experiments	6
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams to calculate the performance parameters of electrical machines.	5
	PO 10	**Communicate** effectively on **complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and **write effective reports and design documentation**, make effective presentation and give and receive clear instructions.	2
	PO 12	Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the context of employability and higher education	4
CO 4	PO 1	**Understand** necessity and conditions for synchronization of alternators with **knowledge of mathematics and engineering sciences.**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	**Demonstrate** the load sharing of alternators under various loading conditions using **complex engineering problems with first principles of mathematics and engineering sciences**	5
	PO 4	Calculate the load sharing of synchronized alternator using research-based knowledge and research methods including design of experiments	6
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams to analyse the impartane of parallel operation.	5
	PO 10	**Communicate** effectively on **complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and **write effective reports and design documentation**, make effective presentation and give and receive clear instructions.	2
	PO 12	Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the context of employability and higher education	4
	PSO 1	**Understand** parallel operation of alternators using electrical systems involving in **power generation**	4
CO 5	PO 1	**Understand** the effects of excitation on synchronous motor performance with the **knowledge of engineering sciences**	2
	PO 2	**Demonstrate** the effect of excitation and variable load on performance of synchronous motor using **first principles of mathematics and engineering sciences**	5
	PO 3	Calculate power factor and excitation of synchronous motorusing using **design solutions for complex engineering problems**	5
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams to understand excitation and power circles.	5
	PO 10	**Communicate** effectively on **complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and **write effective reports and design documentation**, make effective presentation and give and receive clear instructions.	2
	PO 12	Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the context of employability and higher education	4
	PSO 1	**Explain** the effect of variable excitation and load on synchronous motor used in transmission, distribution	4

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	4	5	-	-	-	-	-	-	-	-	-	4	-	-
CO 2	2	4	5	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	5	5	-		-	-	-	-	-	-		-	-	-
CO 4	2	5	-	-	-	-	-	-	-	-	-	-	4	-	-
CO 5	2	5	4	-	-	-	-	-	-	-	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.6	40	50	-	-	-	-	-	-	-	-	-	80	-	-
CO 2	66.6	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	50	50	-		-	-	-	-	-	-		-	-	-
CO 4	40	50	-	-	-	-	-	-	-	-	-	-	80	-	-
CO 5	66.6	50	40	-		-	-	-	-	-	-		-	-	-

XV COURSE ARTICULATION MATRIX (PO - PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 - $5 < C \leq 40\%$ – Low/ Slight
2 - $40\% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	2	-	-	-	-	-	1	1	-	2	2	-	-
CO 2	3	1	-	-	-	-	-	-	1	1	-	2	2	-	-
CO 3	3	2	2	1	-	-	-	-	1	1	-	2	-	-	-
CO 4	1	2	-	1	-	-	-	-	1	1	-	2	2	-	-
CO 5	2	2	1	-	-	-	-	-	1	1-	-	2	-	-	-
TOTAL	**12**	**8**	**5**	**1**	**0**	**0**	**0**	**0**	**5**	**5**	**0**	**10**	**6**	**0**	**0**
AVERAGE	**2.4**	**1.6**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**2**	**2**	**0**	**0**

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Quiz	✓	Tech - Talk	-	Certification	-
Term Paper	-	Seminars	✓	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	✓	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
x	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts	-	-

XVIII SYLLABUS:

UNIT I	**THREE PHASE INDUCTION MACHINES**
	Magnetic fields: Constant magnetic field, pulsating magnetic field, rotating magnetic field; Three phase induction motors: Construction, types of induction motors, slip and frequency of rotor currents, rotor MMF and production of torque, equivalent circuit, power across air gap, torque and power output, torque slip characteristics, generating and braking modes, maximum (breakdown) torque, starting torque, maximum power output, problems. Equivalent circuit model; Induction generator
UNIT II	**TESTING AND SPEED CONTROL OF INDUCTION MOTORS**
	Testing: Brake test, no load and blocked rotor test, circuit model, circle diagram, determination of induction motor parameters from circle diagram, problem. Starting methods: Slip ring induction motor and squirrel cage induction motor starting methods; Speed control of induction motors, problems
UNIT III	**ALTERNATORS**
	Synchronous generators: Introduction, principle of operation, constructional features, armature windings, integral slot and fractional slot windings, distributed and concentrated windings, winding factors, basic synchronous machine model, circuit model of a synchronous machine, armature reaction, phasor diagrams,. Voltage regulation: Determination of synchronous impedance, short circuit ratio, and leakage reactance, Calculation of regulation by synchronous impedance method, MMF, ZPF and ASA methods; Parallel operation of alternators, synchronization of alternators; Slip test, problems.
UNIT IV	**SYNCHRONOUS MOTORS**
	Single phase induction motor: Principle of operation, two reaction theory, equivalent circuit analysis, split phase motor, construction, principle of operation, capacitor start, capacitor run, capacitor start - capacitor run motor, shaded pole motor, torque speed characteristics.

UNIT V	**SINGLE PHASE INDUCTION MOTORS**
	Single phase induction motor: Principle of operation, two reaction theory, equivalent circuit analysis, split phase motor, construction, principle of operation, capacitor start, capacitor run, capacitor start - capacitor run motor, shaded pole motor, torque speed characteristics of single phase induction motors.

TEXTBOOKS

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2. P S Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
3. I J Nagrath and D P Kothari, "Electric Machines", McGraw Hill Education, 2010.

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1. M G Say, "Alternating Current Machines", Pitman Publishing Ltd, 4th Edition, 1976.
2. P C Sen, "Principles of Electric Machines and Power Electronics", John Wiley & Sons, 2007.
3. S K Bhattacharya, "Electrical Machines", TMH publication, 2nd Edition, 2006.

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2. https://www.cet.edu.in
3. https://gndec.ac.in

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XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Lecture on Outcome based education		
CONTENT DELIVERY (THEORY)			
2	Constant magnetic field, pulsating magnetic field, alternating current in windings with spatial displacement	CO 1	T2: 3.2-3.3
3	Addition of pulsating magnetic fields. Three windings spatially shifted by 120 degrees (carrying three-phase balanced currents)	CO 1	T2: 3.2-3.3
4	Revolving magnetic field	CO 1	T2: 3.2-3.3
5	Construction and working principle of three phase induction motor	CO 2	T2: 6.2

6	Torque production and various torque relations in induction motor	CO 2	T2: 6.9
7	Equivalent circuit of poly phase induction motor	CO 2	T2: 6.8
8	Power flow diagram and losses, efficiency of induction motor	CO 2	T2: 6.6
9	Torque – slip and torque – speed characteristics of three phase induction motor	CO 2	T2: 6.9
10	Brake test, no load and blocked rotor test on three phase induction motor	CO 3	T2: 6.11
11	Circle diagram procedure	CO 3	T2: 6.12
12-13	Speed control methods of three phase induction motor	CO 3	T2: 6.14
14-15	Starting methods of three phase induction motor	CO 3	T2: 6.14
16	Induction generator principle of operation	C0 2	T2: 6.16
17	Principle operation and constructional features of synchronous generator	CO 2	T2: 5.1
18	Armature reaction of alternator	CO 2	T2: 5.1
19	Types of armature windings	CO 1	T2: 7.1
20	EMF equation and winding factors	CO 1	T2: 7.1
21	Determination of voltage regulation of alternator by synchronous impedance method (EMF)	CO 3	T2: 5.4.1
22	Determination of voltage regulation of alternator by zero power factor method (ZPF)	CO 3	T2: 5.4.2
23	Determination of voltage regulation of alternator by zero power factor method (ZPF)	CO 3	T2: 5.4.3
24	Determination of voltage regulation of alternator by ASA method	CO 3	T2: 5.4.4
25	Synchronization and Parallel operation of alternators	CO 4	T2: 5.13
26	Blondel's two reaction concept for salient pole alternator	CO 4	T2: 5.16
27	Power developed by salient pole synchronous machine and power angle curve	CO 5	T2: 5.12
28	Principle of operation and constructional features of synchronous motor	CO 2	T2: 5.1
29	Starting methods of synchronous motor	CO 3	T2: 5.20
30	Power developed and power flow within synchronous motor	CO 5	T2: 5.12
31	Equivalent circuit of synchronous motor and synchronous motor with different Excitations	CO 3	T2: 5.6
32	Synchronous motor on load with constant excitation and different torques associated with a synchronous motor	CO 5	T2: 5.7
33	Synchronous motor phasor diagrams for different excitations at constant load	CO 5	T2: 5.7
34	Torque and power relations in synchronous motor	CO 2	T2: 5.13
35	Power and excitation circles of synchronous motor	CO 5	T2: 5.9
36	Two reaction concepts for salient pole synchronous motor	CO 3	T2: 5.16
37	Double revolving and cross field theory	CO 2	T3:3.6.8
38	Split phase motor, construction, principle of operation, torque speed characteristics	CO 2	T3:3.6.8

39	Principle of operation, torque speed characteristics of capacitor start, capacitor run induction motors	CO 2	T3:3.6.8
40	Principle of operation and torque speed characteristics of shaded pole motor	CO 2	T3:3.6.8
41	Equivalent circuit analysis of single-phase induction motor	CO 2	T3:3.6.2
PROBLEM SOLVING/ CASE STUDIES			
42	Calculate slip, speed and equivalent circuit parameters of three phase induction motor	CO 2, 3	T3: 6.9-6.14
43	Calculate torque and find condition for maximum torque of three phase induction motor	CO 2, 3	T3: 6.9-6.14
44	Calculate power developed, efficiency and losses of three phase induction motor	CO 2, 3	T3: 6.9-6.14
45	Calculate various parameters of three phase induction motor from circle diagram	CO 3	T3: 6.9-6.14
46	Numerical problems related to starting methods of three phase induction motor	CO 3	T3: 6.9-6.14
47	Numerical problems on speed control methods of three phase induction motor	CO 3	T3: 6.9-6.14
48	Calculate induced EMF, pitch factor, distribution factor	CO 1	T2: 7.1
49	Calculate power developed and efficiency of alternator	CO 2	T2: 7.1
50	Calculate power developed and efficiency of alternator	CO 2	T2: 7.1
51	Numerical problems related to synchronization and load sharing of alternators	CO 4	T2: 5.13
52-55	Estimate voltage regulation of alternator using various methods like EMF, MMF, ZPF and ASA methods	CO 3	T2: 5.4
56	Calculate equivalent circuit parameters of single-phase induction motor	CO 3	T3:3.6.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Constant, pulsating and revolving magnetic fields and properties of ferro magnetic materials	CO 1	T2: 3.2-3.3
58	Faradays laws, slip, slip speed, RMF, Torque, losses starting and speed control of three phase induction motor	CO 2, 3,	T3: 6.9-6.14
59	Synchronous speed, voltage regulation, armature windings, winding factors, synchronization of alternators	CO 1, 3, 4	T2: 5.1-5.20
60	Back EMF, load angle, internal angle, power factor, excitation, starting methods, synchronous condenser of synchronous motor	CO 3, 5	T3:36.8
61	Double revolving and cross fields, centrifugal switch, auxiliary and starting winding of single phase induction motor	CO 2	T3:36.8
DISCUSSION OF QUESTION BANK			
62	UNIT - I	CO 1	T2: 3.2-3.3
63	UNIT - II	CO 2, 3	T3: 6.9-6.14
64	UNIT - III	CO 1, 2, 3, 4	T2: 5.1-5.20

65	UNIT - IV	CO 2, 3, 5	T2: 7.1-7.20
66	UNIT - V	CO 2, 3	T3:36.8

Course Coordinator **HOD,EEE**
Mr K.Devender Reddy, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Electrical Measurements and Instrumentation**				
Course Code	AEE008				
Program	B.Tech				
Semester	IV				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Dr. M Laxmidevi Ramanaiah, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE005	III	Network Analysis
B.Tech	AEE006	III	Electromagnetic Field Theory

II COURSE OVERVIEW:

This course introduces and develops the basic understanding of measurement principles and measuring instruments used in numerous electrical applications. The course provides the concept of measurement, analysis of errors and various specification parameters used to judge and compare measuring instruments. It provides an insight to develop advanced instruments in industries.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electrical Measurements and Instrumentation	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
30%	Understand
20%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz/ Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

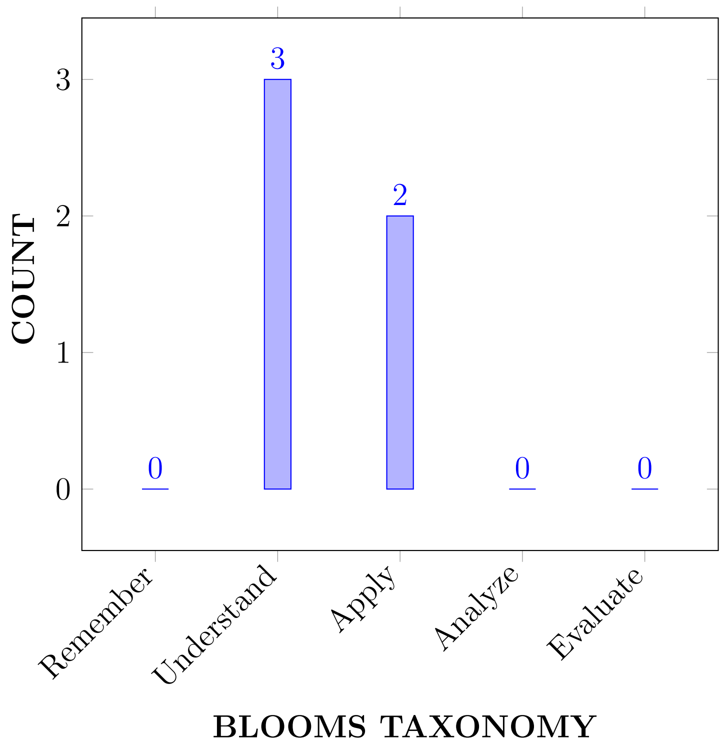
I	The types and characteristics of instruments employed for measuring electrical quantities.
II	The construction, operation and maintenance of different types of instruments.
III	The concepts of Cathode Ray Oscilloscope and transducers to measure the physical quantities in the field of science, engineering and technology.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Illustrate** the working of PMMC, MI and electrostatic voltmeter in view of principle of operation, construction, extension of range and various errors.	Understand
CO 2	**Make use of** potentiometer and instrument transformers in view of construction, extension of range and various errors.	Understand
CO 3	**Demonstrate** the construction and operation of wattmeter and energy meter for obtaining power and energy in single phase and three phase networks.	Understand
CO 4	**Select** the DC and AC bridges suitable for the measurement of passive parameters.	Apply
CO 5	**Summarize** various working models, features and applications of transducers and oscilloscopes.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations

Program Outcomes	
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/CIA
PO 2	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	SEE/CIA
PO 3	Design/Development of Solutions: Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	SEE/CIA

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	SEE/CIA

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	2	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	✓	-	-	-	-	-	-	✓	-	-	✓	-	-
CO 2	✓	✓	✓	-	-	-	-	-	-	✓	-	-	✓	-	-
CO 3	✓	✓	✓	-	-	-	-	-	-	✓	-	-	✓	-	-
CO 4	✓	✓	✓	-	-	-	-	-	-	✓	-	-	-	-	-
CO 5	✓	✓	-	-	-	-	-	-	-	✓	-	-	-	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall the instruments used for measuring electrical quantities,Faraday's laws of electromagnetic induction, the concept of torque and error,phenomenon of electrostatic effect using the principles of mathematics, science and engineering fundamentals.	3
	PO 2	Determine the expressions for torque in PMMC, MI and electrostatic instruments to solve complex engineering problems problems using principles of mathematics and engineering sciences. .	5
	PO 3	Design the solution for problems to minimize errors in PMMC, MI and electrostatic instruments.	5

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 10	Demonstrate the ability to communicate effectively in writing /orally to obtain the solutions for problems to minimize errors in PMMC, MI and electrostatic instruments.	2
	PSO 1	Understand the characteristics of different measuring instruments for the operation and control of electrical power system.	1
CO 2	PO 1	Recall the working of potentiometer the principle of electromagnetic induction which helps in structuring the principles of instrument transformer with the fundamentals of mathematics, science, and engineering fundamentals. .	3
	PO 2	Derive the expression for the different types of errors encountered in instrument transformers to analyze complex engineering problems using principles of mathematics and engineering sciences.	4
	PO 3	Illustrate the expression for phase angle error and ratio error to operate at desired specifications of electrical components in power systems.	3
	PO 10	Demonstrate the ability to communicate effectively in writing /orally for minimizing phase angle error and ratio error to operate at desired specifications of electrical components in power systems.	2
	PSO 1	Understand the importance of current transformer and potential transformer for protection in power system.	3
CO 3	PO 1	Understand the behavior of current carrying conductor placed in magnetic field and the principle of induction effect with the help of basic fundamentals of mathematics science and engineering fundamentals.	3
	PO 2	Derive the expression for torque in wattmeter to solve complex engineering problems using basic mathematics and engineering principles.	6
	PO 3	Determine power losses in power system to reduce these losses in power system.	2
	PO 10	Demonstrate the ability to communicate effectively in writing /orally to find solutions to power system problems.	2
	PSO 1	Understand the principle of power balance to ensure efficient operation of electrical system.	3
CO 4	PO 1	Explain the concept of null deflection with the help of fundamentals of mathematics, science, and engineering fundamentals.	3
	PO 2	Derive the expression for balanced bridge with the help of fundamentals of mathematics, science, and engineering fundamentals.	5
	PO 3	Determine the resistance, inductance and capacitance of different electrical components to design electrical components.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 10	Demonstrate the ability to communicate effectively in writing /orally to understand the problems based on passive parameters.	2
CO 5	PO 1	Identify the different non-electrical parameters and recall the working of cathode ray oscilloscope applying basic knowledge of science and engineering fundamentals.	3
	PO 2	Illustrate the different methods for the measurement of non-electrical parameters which helps to solve complex engineering problems	5
	PO 10	Demonstrate the ability to communicate effectively in writing /orally to understand non-electrical parameter measurement.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	5	5	-	-	-	-	-	-	2	-	-	1	-	-
CO 2	3	4	3	-	-	-	-	-	-	2	-	-	3	-	-
CO 3	3	6	2	-	-	-	-	-	-	2	-	-	3	-	-
CO 4	3	5	2	-	-	-	-	-	-	2	-	-	-	-	-
CO 5	3	5	-	-	-	-	-	-	-	2	-	-	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	50	50	-	-	-	-	-	-	40	-	-	20	-	-
CO 2	100	40	30	-	-	-	-	-	-	40	-	-	60	-	-
CO 3	100	60	20	-	-	-	-	-	-	40	-	-	60	-	-
CO 4	100	50	20	-	-	-	-	-	-	40	-	-	-	-	-
CO 5	100	50	-	-	-	-	-	-	-	40	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 - $5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	2	-	-	-	-	-	-	1	-	-	1	-	-
CO 2	3	1	1	-	-	-	-	-	-	1	-	-	3	-	-
CO 3	3	3	1	-	-	-	-	-	-	1	-	-	3	-	-
CO 4	3	2		-	-	-	-	-	-	1	-	-	-	-	-
CO 5	3	2	-	-	-	-	-	-	-	1	-	-	-	-	-
TOTAL	15	10	4	-	-	-	-	-	-	5	-	-	7	-	-
AVERAGE	3	2	1.25	-	-	-	-	-	-	1	-	-	2.3	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	-	-	-	-	

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

UNIT I	**INTRODUCTION TO MEASURING INSTRUMENTS**
	Introduction: Classification of measuring instruments, deflecting, damping and control torques, types of errors, ammeter and voltmeter: PMMC, MI instruments, expression for deflection and control torque, errors and compensation, extension of range using shunts and series resistances; Electro static voltmeter: attracted type, disc type, extension of range of voltmeters, electro dynamic type voltmeters
UNIT II	**POTENTIOMETERS AND INSTRUMENT TRANSFORMERS**
	DC Potentiometers: Principle and operation of Crompton potentiometer, standardization, measurement of unknown resistance, current, voltage; AC potentiometers: polar and coordinate type, standardization, applications; Instrument transformers: CT and PT, ratio and phase angle error.
UNIT III	**MEASUREMENT OF POWER AND ENERGY**
	Measurement of Power: Single phase dynamometer type wattmeter, LPF and UPF, double elements and three elements dynamometer wattmeter; Expression for deflection and control torque, extension of range of wattmeter by using instrument transformers, measurement of active and reactive power for balanced and unbalanced Systems. Measurement of Energy: Single phase induction type energy meter, driving and braking torques, errors and compensations, testing by phantom loading using RSS meter, three phase energy meter, introduction to net energy metering (web ref: 4 and 5), maximum demand meters.

UNIT IV	**DC AND AC BRIDGES**
	Measurement of Resistance: Methods of measuring low, medium, high resistance, Wheatstone bridge, carry foster, Kelvin's double bridge, loss of charge method; Measurement of Inductance: Maxwell's bridge, Hay's bridge, Anderson's bridge, Owen's bridge; Measurement of Capacitance: Desauty's bridge, Wein's bridge, Schering bridge.
UNIT V	**TRANSDUCERS AND OSCILLOSCOPES**
	Transducers: Definition of transducers, classification of transducers, advantages of electrical transducers, characteristics and choice of transducers, principle of operation of LVDT and capacitor transducers, LVDT applications, strain gauge and its principle of operation, gauge factor, thermistors, thermocouples, synchros, piezo-electric transducers, photovoltaic, photo conductive cells, photo diodes; Cathode ray oscilloscope: Cathode ray tube, time base generator, horizontal and vertical amplifiers, CRO probes, applications of CRO, measurement of phase and frequency, Lissajous patterns, sampling oscilloscope, analog oscilloscope, tubeless oscilloscopes, digital storage oscilloscope (web ref: 6).

TEXTBOOKS

1. A K Sawhney, —Electrical and Electronic measurement and instruments, Dhanpat Rai and Sons Publications, 2002

2. E W Golding and F C Widdis , Electrical measurements and measuring instruments,Wheeler publishing, 2006

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1. Buckingham and Price, —Electrical measurements, Prentice Hall

2. D V S Murthy, Transducers and Instrumentation, Prentice Hall of India, London, 2009.

3. A S Morris, Principles of measurement of instrumentation, Pearson/Prentice Hall of India, 1994.

4. H S Kalsi,Electronic Instrumentation, Tata McGraw-Hill Publications, 1995.

WEB REFERENCES:

1. https://nptel.ac.in/courses/108/105/108105153/

COURSE WEB PAGE:

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Presentation on Outcome based education		
CONTENT DELIVERY (THEORY)			
2	Classification of measuring instruments	CO 1	T1: 6.1
3	Types of torques	CO 1	T1: 6.4
4	PMMC instruments	CO 1	T1: 8.5
5	MI instruments	CO 1	T1: 8.1

6-7	Extension of range using shunt and series resistances	CO 1	T1: 8.8
8	Electro static voltmeter	CO 1	T1: 8.67
9-10	Crompton potentiometer	CO 2	T1: 14.1
11-12	Applications of DC potentiometers	CO 2	T1: 14.12
13-14	Applications of AC potentiometersor	CO 2	T1: 14.21
15	Current transformer	CO 2	T1: 9.5
16	Potential transformer	CO 2	T1: 9.17
17	Errors in Instrument transformers	CO 2	T1:9.7
18	Single phase dynamometer type wattmeter	CO 3	T1: 10.3
19-20	Measurement of active power for balanced and unbalanced systems.	CO 3	T1: 10.19
21	Measurement of reactive power for balanced and unbalanced systems.	C0 3	T1: 10.21
22	Single phase induction type energy meter	CO 3	T1: 11.6
23	Three phase energy meter	CO 3	T1: 11.15
24	Measurement of low resistance	CO 4	T1: 13.12
25	Measurement of medium resistance	CO 4	T1: 13.2
26	Measurement of high resistance	CO 4	T1: 13.19
27-28	Measurement of Inductance	CO 4	T1: 16.5
29-30	Measurement of Capacitance	CO 4	T1: 16.11
31	Classification of transducers	CO 5	T1: 25.11
32	Principle of operation of LVDT	CO 5	T1: 25.1
33	Thermistors, Thermocouples	CO 5	T1: 25.22
34	Photovoltaic,Photoconductive cells and Photo Diodes	CO 5	T1: 25.1
35	Measurement of Strain, Gauge Sensitivity	CO 5	T1: 25.18
36	Piezo-electric transducers	CO 5	T1: 25.31
37	Cathode ray oscilloscope	CO 5	T1: 21.11
38	Sampling oscilloscopes	CO 5	T1: 21.17
39	Analog oscilloscopes	CO 5	T1: 21.1
40	Digital storage oscilloscopes	CO 5	T1: 21.21
41	Lissajous pattern	CO 5	T1: 21.14
PROBLEM SOLVING/ CASE STUDIES			
42	A moving-coil instrument gives a full scale deflection. When the current is 40 mA and its resistance is 25Ohms. Calculate the value of the shunt to be connected in parallel with the meter to enable it to be used as an ammeter for measuring currents up to 50 A.	CO 1	T1:8.1
43	A meter of resistance 50 ohm has a full scale deflection of 4 mA. Determine the value of shunt resistance required in order that full scale deflection should be i) 15 mA ii) 20 A iii) 100 A	CO 1	T1:8.1

44	The capacity of an electrostatic voltmeter ranging from 0 to 2000 V increases from 80 to 90pF as the pointer moves from zero to full scale deflection. Calculate the value of external capacitor used to increase its range to 20 kV. If the capacitor is adjusted to make the full scale reading correct, what will be the error at half scale reading	CO 1	T1:8.1
45	A potential transformer ratio 2000/100 V has the following constants: Primary resistance = 105 ohms, secondary resistance = 0.7Ω, primary reactance = 75.2Ω, total equivalent reactance = 0.087Ω, no-load current at 0.03 A at 0.36 power factor lagging. Solve for phase angle error on no load , phase angle error on a load of 5 A at 0.92 lagging power factor and burden in VA at unity power factor at which the phase angle will be zero.	CO 2	T1:9.1
46	Develop a volt- ratio box with a resistance of 20 ohms/V and ranges 3 V, 10V, 30 V, 100 V. the volt-ratio box is to be used with a potentiometer having a measuring range of 1.5 V	CO 2	T1:9.1
47	A current transformer with bar primary has 300 turns in its secondary winding. The resistance and reactance of the secondary circuit are 1.5ohm and 1.0ohm respectively, including the transformer winding. With 5A flowing in the secondary winding, the magnetizing mmf is 100AT and the core loss is 1.2 W. Identify the ratio and phase angle errors	CO 2	T1:9.1
48	A wattmeter has a current coil of 0.1 ohms resistance and a pressure coil of 6500Ω resistance. Calculatethepercentageer-rors,duetoresistanceonlywitheachofthetwomethodsofconnection of wattmeter when reading the input to an apparatus which takes i) 12 A at 250 V with unity power factor and ii) 12 A at 250 V and 0.4 power factor.	CO 2	T1:10.1
49	A 500V,20A dynamometer instrument is used as a wattmeter. Its current coil has 0.1ohm resistance and pressure coil has 25kohm resistance with 0.1 H inductance. The meter was calibrated on DC supply. Solve for the error in the instrument if it is used to measure the power in a circuit with supply voltage of 500 V, load current of 24 A at 0.2 P.f. assume that pressure coil is connected across load?	CO 3	T1:10.1
50	An energy meter is designed to make 100 revolutions of the disc for one unit of energy. Solve for the number of revolutions made by it when connected to a load carrying 20 A at 230 V at 0.8 p.f. for an hour. If it actually makes 360 revolutions, find the percentage error?	CO 3	T1:11.1
51	The four arms of the Hay's bridge at balances are: Arm AB: Coil of unknown impedance. Arm BC : A non-reactive resistance of 100 ohms,Arm CD : A non-reactive resistance of 833 ohms in series with 0.38 uF capacitor. Arm DA : A non-reactive resistance of 16800 ohms. If the supply frequency is 50 Hz, Solve for the inductance and resistance at the balance condition	CO 4	T1:16.1

52	A Kelvin's double bridge is balanced with the following constants. Outer ratio = 100 ohms and 1000 ohms, Inner ratio arms = 99.92 ohms and 1000.6 ohms, resistance of link = 0.1 ohms, Standard resistance = 0.00377 ohms, calculate the value of unknown resistance.	CO 4	T1:16.1
53	The four arm bridge ABCD, supplied with a sinusoid voltage, have the following values: AB = 330 ohms resistance in parallel with 0.2 uF capacitor.BC = 400 ohms resistance, CD = 800 ohms resistance: DA R in series with a 1.5 uF capacitor. Identify the value of R and supply frequency at which bridge will be balanced.	CO 4	T1:16.1
13	A CRT has anode voltage of 2000V and parallel deflecting plates 1.5 cm long and 5 mm apart. The screen is 50 cm from the center of the plates. Solve for i) beam speed (ii) deflection sensitivity (iii) deflection factor of the tube	CO 5	T1:21.1
54	A parallel plate capacitive transducer has a plates of 600 mm2 area which are separated by air by a distance of 0.2mm. The resistance of the transducer is 20x106ohm.Calculate the time constant of the transducer and fined the attenuation of the output at 1000Hz. The resistivity of air is 8.85x10^{-12} F/m.	CO 5	T1:21.1
55	A Lissajous pattern on the CRT screen is stationary and has 2 vertical tangencies and 5 horizontal tangencies. If the frequency of horizontal input is1000 Hz. Calculate the frequency of the vertical input.	CO 5	T1:21.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Instrument,Static srror, Range	CO 1	T1:1.1,6.1 8.1
57	Potentiometer, Volt ratio box, Standardization,burden, ratio correction factor, nominal ratio, transformation ratio	CO 2	T1:14.1, 19.1
58	Two-element wattmeter,Pressure coil, Creeping error , net energy metering,maximum demand, Phantom Loading	CO 3	T1:10.1, 11.1
59	DC bridge, AC bridge, Loss of Charge Method	CO 4	T1:13.1, 16.1
60	Transducer, Pressure transducer,Thermocouple, piezoelectric sensor,Photodiode, Photocell,sampling oscilloscope,Sweep time, Lissajous pattern	CO 5	T1:25.1, 21.1
DISCUSSION OF QUESTION BANK			
61	UNIT I: PMMC, MI instruments	CO 1	T1:1.1,6.1, 8.1
62	UNIT II: Instrument transformer and Potentiometers	CO 2	T1:14.1, 19.1
63	UNIT III: Wattmeter and Energy meter	CO 3	T1:10.1, 11.1
64	UNIT IV : AC and DC bridges	CO 4	T1:13.1, 16.1
65	UNIT V: Transducers and Oscilloscopes	CO 5	T1:25.1, 21.1

Signature of Course Coordinator **HOD,EEE**
Dr M Laxmidevi Ramanaiah

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**

PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**

PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**

PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**
PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**
PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer. 1. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**CONTROL SYSTEMS**				
Course Code	AEE009				
Program	B.Tech				
Semester	IV				
Course Type	CORE				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	3	1.5
Course Coordinator	Ms.K Harshini, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSB11	II	Mathematical Transform Techniques
B.Tech	AEEB11	III	Electrical Machines – I

II COURSE OVERVIEW:

This course deals with the basic concepts of block diagram reduction technique, time response analysis of first order and second order systems. It deals with various time and frequency domain analysis. It elaborates the concept of stability and its assessment for linear time invariant systems. This course address the various real time issues and how the control strategies are used in automation areas associates with variety of engineering streams.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Control Systems	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
✓	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), and 10 marks for Alternative Assessment Tool (AAT).

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
66.7 %	Understand
33.3%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
	Continuous Internal Examination – 2 (Mid-term)	10	
	AAT-1	5	
	AAT-2	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			100

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

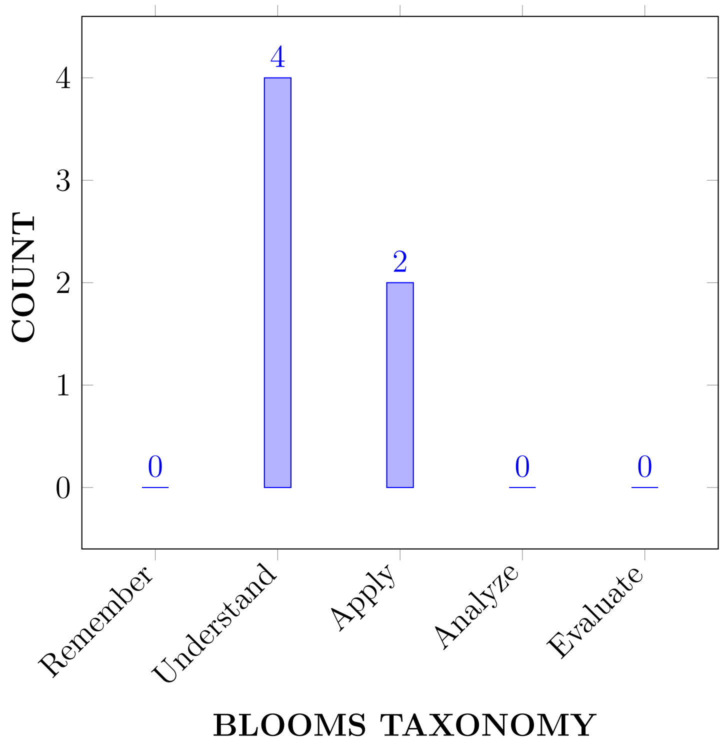
I	The mathematical models of dynamic systems using the concepts of basic sciences.
II	The system performance using time domain and frequency domain analysis for standard inputs.
III	Classification of controllers and compensators as per the desired dynamic response of the system.
IV	The different ways of system representation such as transfer function and state space.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Relate** the different physical and mechanical systems into equivalent electrical analogies using the mathematical form of complex physical systems.	Understand
CO 2	**Utilize** various reduction techniques for developing the transfer function and steady state error with the standard input signals.	Apply
CO 3	**Make use of** the time domain analysis to predict transient response specifications for analysing system's stability	Apply
CO 4	**Infer** the stability of a first and second order systems using frequency domain specifications.	Understand
CO 5	**Classify** the types of compensators in time domain and frequency domains specifications for increasing the steady state accuracy of the system.	Understand
CO 6	**Interpret** linear system equations in state-variable form for the analysis of system's dynamic behavior.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Program Outcomes	
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/Quiz/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	CIE/Quiz/AAT
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	CIE/Quiz/AAT
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	2	CIE/Quiz/AAT
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	CIE/Quiz/AAT
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	1	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, develop fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.	1	Research Paper / Quiz / AAT
PSO 2	Focus on the components of electrical drives with its converter topologies, for energy conversion, management and auditing in specific applications of industry and sustainable rural development.	1	Research Paper / Quiz / AAT

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer.	1	Research Paper / Quiz / AAT

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	✓	✓	-	✓	-	-	-	✓	-	✓	-	-	✓
CO 2	✓	✓	✓	✓	-	✓	-	✓	-	✓	-	✓	✓	-	-
CO 3	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	✓	-	-
CO 4	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	✓	-
CO 5	✓	✓	✓	✓	-	✓	-	✓	-	✓	-	✓	✓	✓	-
CO 6	✓	✓	✓	-	-	✓	-	-	-	-	-	-	-	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	**PO 1**	Understands the concept of control systems and its types with the knowledge of mathematics, science and engineering fundamentals.	3
	PO 2	Determine the mathematical model of complex systems by analyze complex engineering problems using principles of mathematics and engineering sciences.	7
	PO 3	Design the equivalent electrical models using force-voltage and force-current analogy by analyze complex engineering problems using principles of mathematics and engineering sciences.	7
	PO 4	Analyze the characteristics of Motors of Field and Armature control by conducting some investigations using technical literature and research based knowledge	5
	PO 6	Understands the concept of open loop and closed loop with examples informed by the contextual knowledge to assess societal engineering practice.	3
	PO 10	Understands the basics of control systems and should be able to communicate effectively on engineering activities	2
	PO 12	Recognize the types of control systems is what we use in daily life through the preparation and ability in personal development.	2
	PSO 3	Understands the operation of open and closed loop control systems to meet the requirements of the employer.	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	**PO 1**	Explain the different complex physical systems with the knowledge of mathematics, science, and engineering fundamentals.	3
	PO 2	Determine the mathematical model of complex systems by analyze complex engineering problems using principles of mathematics and engineering sciences.	6
	PO 3	Design the solution for analyze complex engineering problems using principles of mathematics and engineering sciences.	7
	PO 4	Analyze the behavior of first and second order system with different standard inputs by conducting some investigations using technical literature and research based knowledge	5
	PO 6	Understands the concept of various controllers and how they are applicable to the contextual knowledge to assess societal engineering practice.	3
	PO 8	Knowledge of various controllers ability to use their application to professional ethics and responsibilities and norms of the Engineering practice	3
	PO 10	Understands the basics of controllers and various types of system should be able to communicate effectively on engineering activities	2
	PO 12	Recognize the types of controllers is what we use in daily life through the preparation and ability in personal development.	3
	PSO 1	Design and operate controllers in electrical systems in order to protect the system.	1
CO 3	**PO 1**	Understand the concept of stability of the system from the characteristic equation using principles of mathematics, science, and engineering fundamentals.	3
	PO 2	Formulate the mathematical equations for a system's stability framed using basics of mathematics and engineering sciences	5
	PO 3	Design the solution for a system of unity feedback by analyze complex engineering problems using principles of mathematics and engineering sciences.	5
	PO 4	Analyze the nature of stability of the type of system by conducting some investigations using technical literature and research based knowledge	5
	PO 6	Understands the concept of stability of open and closed loop system and type of feedback from the contextual knowledge to assess societal engineering practice.	3
	PSO 1	Design and operate controllers in electrical systems in order to protect the system.	1
CO 4	**PO 1**	Understand the concept of frequency response of a system using principles of mathematics, science, and engineering fundamentals.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Derive frequency domain specifications and correlation between time and frequency domain framed using basics of mathematics and engineering sciences.	4
	PO 3	Determine the frequency response of a system by analyze complex engineering problems using principles of mathematics and engineering sciences.	7
	PO 4	Analyze the magnitude and phase plot by conducting some investigations using technical literature and research based knowledge	7
	PO 6	Understands the concept of frequency response of a system from the contextual knowledge to assess societal engineering practice.	3
	PSO 2	Understands frequency response of a system involving transmission and distribution of Electrical Energy	1
CO 5	**PO 1**	Understands the concept of compensators and its types using the fundamentals of mathematics, science, and engineering fundamentals.	3
	PO 2	Derive the equation for lead, lag, lead-lag compensators to meet the specifications framed using basics of mathematics and engineering sciences.	5
	PO 3	Determine the frequency response of a system by analyze complex engineering problems using principles of mathematics and engineering sciences.	7
	PO 4	Analyze the behavior of types of compensators by conducting some investigations using technical literature and research based knowledge	7
	PO 6	Understands the concept of various compensators and how they are applicable to the contextual knowledge to assess societal engineering practice.	2
	PO 8	Knowledge of various compensators ability to use their application to professional ethics and responsibilities and norms of the Engineering practice	3
	PO 10	Understands the basics of compensators and various types of system should be able to communicate effectively on engineering activities	2
	PO 12	Recognize the types of compensators is what we use in daily life through the preparation and ability in personal development.	2
	PSO 1	Design and operate compensators in electrical systems in order to protect the system.	2
	PSO 2	Control the system's power utilization in electrical systems in specific applications of industry and sustainable rural development.	2
CO 6	**PO 1**	Understands state model of control system using its block diagram using basic knowledge of science and engineering fundamentals.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Formulate the state transmission matrix for controllability and observability to evaluate stability of the system framed using basics of mathematics and engineering sciences.	4
	PO 3	Determine the state of stability of a system or a differential linear equation analyze complex engineering problems using principles of mathematics and engineering sciences.	7
	PO 6	Understands the concept of state of stability of a system they are application to the contextual knowledge to assess societal engineering practice.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	7	7	5	-	3	-	-	-	2	-	2	-	-	1
CO 2	3	3	7	5	-	3	-	3	-	2	-	3	2	-	-
CO 3	3	5	5	5	-	3	-	-	-	-	-	-	1	-	-
CO 4	3	4	7	7	-	3	-	-	-	-	-	-	-	1	-
CO 5	3	5	7	7	-	2	-	3	-	2	-	2	2	2	-
CO 6	3	4	7	-	-	2	-	-	-	-	-	-	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	100	66	9	-	60	-	-	-	20	-	8.3	-	-	14.2
CO 2	100	100	66.7	9	-	60	-	100	-	20.0	-	8.3	40.0	-	-
CO 3	100	100	50	9	-	60	-	-	-	-	-	-	20.0	-	-
CO 4	100	66.7	66.7	100	-	60	-	-	-	-	-	-	-	9.09	-
CO 5	100	66.7	66.7	100	-	40	-	100	-	20.0	-	8.3	40.0	18.2	-
CO 6	100	66.7	66.7	-	-	40	-	-	-	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	2	1	-	2	-	-	-	1	-	1	-	-	1
CO 2	3	3	2	1	-	2	-	1	-	1	-	1	2	-	-
CO 3	3	3	3	1	-	3	-	-	-	-	-	-	1	-	-
CO 4	3	2	2	3	-	3	-	-	-	-	-	-	-	1	-
CO 5	3	2	2	3	-	1	-	1	-	1	-	1	2	2	-
CO 6	3	2	2	-	-	1	-	-	-	-	-	-	-	-	-
TOTAL	18	15	13	9	-	12	-	2	-	3	-	3	5	3	1
AVERAGE	3	2.5	2.0	1.8	-	2	-	1	-	1	-	1	1.5	1.5	1

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION AND MODELING OF PHYSICAL SYSTEMS**
	Control systems: Introduction, open loop and closed loop systems, examples, comparison, mathematical modelling and differential equations of physical systems, concept of transfer function, translational and rotational mechanical systems, electrical systems, force, voltage and force, current analogy.
MODULE II	**BLOCK DIAGRAM REDUCTION AND TIME RESPONSE ANALYSIS**
	Block Diagrams: Block diagram representation of various systems, block diagram algebra, characteristics of feedback systems, AC servomotor, signal flow graph, Mason's gain formula; Time response analysis: Standard test signals, shifted unit step, impulse response,unit step response of first and second order systems, time response specifications, steady state errors and error constants, dynamic error coefficients method, effects of proportional, derivative and proportional derivative, proportional integral and PID controllers.
MODULE III	**CONCEPT OF STABILITY AND ROOT LOCUS TECHNIQUE**
	Concept of stability: Necessary and sufficient conditions for stability, Routh's and Routh Hurwitz stability criterions and limitations. Root locus technique: Introduction, root locus concept, construction of root loci, graphical determination of 'k' for specified damping ratio, relative stability, effect of adding zeros and poles on stability.

MODULE IV	**FREQUENCY DOMAIN ANALYSIS**
	Frequency domain analysis: Introduction, frequency domain specifications, stability analysis from Bode plot, Nyquist plot, calculation of gain margin and phase margin, determination of transfer function, correlation between time and frequency responses.
MODULE V	**STATE SPACE ANALYSIS AND COMPENSATORS**
	State Space Analysis: Concept of state, state variables and state model, derivation of state models from block diagrams, diagonalization, solving the time invariant state equations, state transition matrix and properties, concept of controllability and observability; Compensators: Lag, lead, lead - lag networks.

TEXTBOOKS

1. I J Nagrath, M Gopal, "Control Systems Engineering", New Age International Publications, 3rd Edition, 2007.
2. K Ogata, "Modern Control Engineering", Prentice Hall, 4th Edition, 2003
3. N C Jagan, "Control Systems", BS Publications, 1st Edition, 2007.

REFERENCE BOOKS:

1. Anand Kumar, "Control Systems", PHI Learning, 1st Edition, 2007.
2. S Palani, "Control Systems Engineering", Tata McGraw-Hill Publications, 1st Edition, 2001.
3. N K Sinha, "Control Systems", New Age International Publishers, 1st Edition, 2002.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112105171/1

COURSE WEB PAGE:

https://nptel.ac.in/courses/112105171/1

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
	OBE DISCUSSION		
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	-
	CONTENT DELIVERY (THEORY)		
1	Introduction to Control systems	CO 1	T1:1.1
2	Types of Control systems Open loop and Closed loop systems	CO 1	T1:1.1
3	Examples of closed control system and open loop system	CO 1	T1:1.4-1.6
4	Concept of transfer function	CO 1	T1: 2.4
5	Mechanical translational system, Force balance equations.	CO 1	T1:2.2
6	Mechanical rotational system, Torque balance equations.	CO 1	T1:2.2

7	Transfer function of Armature controlled and Field controlled of DC Motor.	CO 1	T1:2.4
8	Force -Voltage and Force-Current Analogy	CO 1	T1:2.2
9	Block Diagrams: Block diagram representation of various control systems	CO 2	T1:2.5
10	Block diagram reduction and Rules of block diagram	CO 2	T1:2.5
11	Characteristics of feedback systems	CO 2	T1: 3.1-3.2
12	AC Servomotor working and characteristics	CO 2	T1: 1..2
13	Signal Flow Graph, properties and rules of signal flow graph	CO 2	T1 :2.6
14	Step by step procedure of transfer function from signal flow graph using Mason's Gain Formula	CO 2	T1 :2.6
15	Time response analysis, Standard test signals	CO 2	T1 :5.1-5.2
16	Impulse response	CO 2	T1 :5.1-5.2
17	Response of first order system for step input	CO 2	T1: 5.3
18	Response of Un damped second order system for step input	CO 2	T1: 5.3
19	Response of Under damped and Over damped second order system for step input	CO 2	T1: 5.3
20	Time Domain specifications of second order system	CO 2	T1: 5.4
21	Steady state errors and error constants	CO 2	T1: 5.5
22	Error constants for various inputs and for different Types of system	CO 2	T1: 5.5
23	PID Controllers	CO 2	T1:5.8
24	Concept of stability Necessary and sufficient conditions for stability	CO 3	T1: 6.1 -6.2
25	Conditions and special cases for stability using Routh's Hurwitz method.	CO 3	T1: 6.3 -6.5
26	Introduction to Root locus concept.	CO 3	T1: 7.1 -7.2
27	Step by step procedure for construction of root locus	CO 3	T1: 7.3
28	Effect of adding zeros and poles on stability.	CO 3	T1: 5.6
29	Frequency domain analysis Introduction	CO 4	T1: 8.1 -8.2
30	Frequency domain specifications, stability analysis	CO 4	T1: 8.2
31	Procedure of Bode Plot for magnitude and phase plot.	CO 4	T1: 8.4
32	Procedure for gain margin and phase margin	CO 4	T1: 8.4
33	Procedure of Nyquist plot for magnitude and phase plot.	CO 4	T1: 9.1-9.4
34	Determination of transfer function, correlation between time and frequency responses	CO 4	T1: 8.1 -8.2
35	State Space Analysis: Concept of state, state variables and state model	CO 6	T1: 12.1-12.2
36	Derivation of state models from block diagrams	CO 6	T1: 12.3-12.4

37	State transition matrix and properties,	CO 6	T1: 12.4
38	Canonical Form of state variables	CO 6	T1: 12.6
39	Concept of controllability and observability	CO 6	T1:12.7
40	Compensators: Lag, lead, lead - lag networks.	CO 5	T1:10.3
PROBLEM SOLVING/ CASE STUDIES			
41	Determine transfer function from mechanical systems	CO 1	R1: 2.6
42	Determine transfer function from electrical systems	CO 1	R1: 2.6
43	Transfer function from Block diagram using reduction technique	CO 2	R1: 3.2
44	Transfer function from Signal Flow Graph using masons gain formula	CO 2	R1: 3.2
45	Problems on Error constants	CO 2	R1: 4.4 Pg No 195-198
46	Problems on time domain specifications	CO 2	R1: 4.4 Pg No 198-209
47	Stability using Routh's Hurwitz method	CO 3	R1:5.3 Pg No 285-292
48	Problems on Root Locus for a given transfer function	CO 3	R1:6.4 Pg No 339-347
47	Problems on Routh's Hurwitz method to find K	CO 3	R1:5.6 Pg No 298-307
48	Problems on Frequency domain specifications	CO 4	R1:7.2 Pg No 413-416
49	Sketch Bode Plot for stability	CO 4	R1:7.3 Pg No 417-427
50	Sketch Bode Plot for gain and phase margin	CO 4	R1:7.4 Pg No 452-465
51	Sketch Polar Plot for gain and phase margin	CO 4	R1:7.3 Pg No 417-427
52	Problems on state model to the canonical form	CO 6	R1:10.3 Pg No 594-597
53	State controllability and observability of a system	CO 6	R1: 10.4 Pg No 661-671
54	Problems on Compensators	CO 5	R1: 9.2
55	Problems on State Transition Matrix	CO 6	R1: 10.7 Pg No 630-639

DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Transfer function, components of feedback control system, Automatic Controllers.	CO 1	T1: 2.4
57	Basic elements in Block Diagram, signal flow graph, transient response, transmittance, Masons Gain formula	CO 2	T1: 3.1-3.2
58	Stability, Routh stability criterion, Auxiliary polynomial, Relative stability	CO 3	T1: 6.3 -6.5
59	Frequency response, Resonant frequency, Corner frequency, Polar plot.	CO 4	T1: 8.1 -8.2
60	State variable, Controllability, Compensator, sampling theorem	CO 5, CO 6	T1: 12.3-12.4
DISCUSSION OF QUESTION BANK			
61	Mechanical Rotational System	CO 1	T1: 2.4
62	Block Diagram, Signal flow graph	CO 2	T1: 3.1-3.2
63	Root Locus and Routh's Hurwitz method	CO 3	T1: 6.3 -6.5
64	Bode plots, polar plot and Nyquist plot	CO 4	T1: 8.1 -8.2
65	State Transmission matrix and compensators	CO 5, CO 6	T1: 12.3-12.4

Signature of Course Coordinator **HOD,EEE**

Mrs K Harshini, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**COMPLEX ANALYSIS AND PROBABILITY DISTRIBUTIONS**				
Course Code	AHS004				
Program	B. Tech				
Semester	IV				
Course Type	Foundation				
Regulation	IARE-R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Ms B Praveena, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
10+2	-	-	-

II COURSE OVERVIEW:

The course focuses on more Advanced Engineering Mathematics which provide with the relevant mathematical tools required in the analysis of engineering problems and scientific professions. The course includes complex functions and differentiation, complex integration, power series expansion of complex function and Probability of single random variables with its distributions. The mathematical skills derived from this course form a necessary base to analytical and design concepts encountered in the program.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Complex Analysis and probability distributions	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), and 10 marks for Alternative Assessment Tool (AAT).

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
36 %	Understand
64 %	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

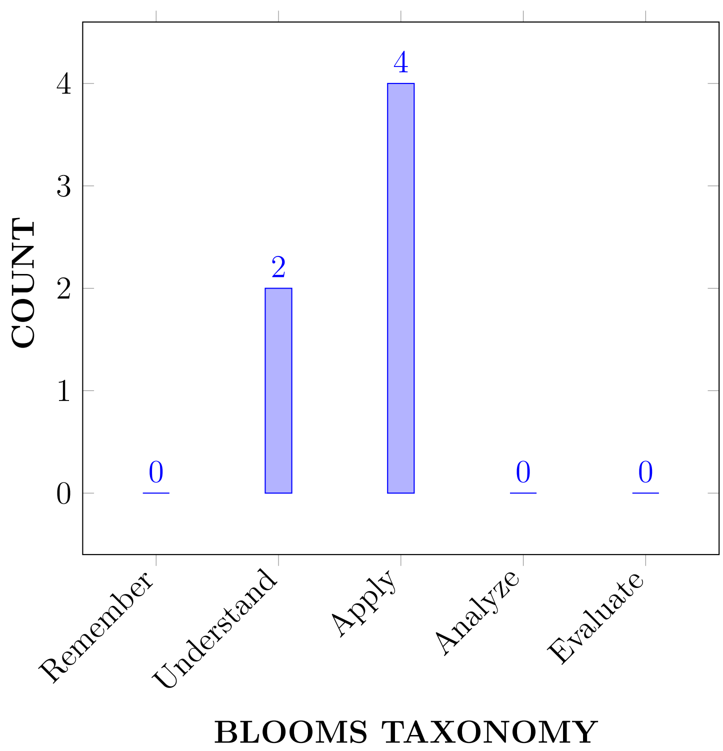
I	The applications of complex variable and conformal mapping in two dimensional complex potential theories.
II	The fundamental calculus theorems and criteria for the independent path on contour integral used in problems of engineering
III	Enrich the knowledge of probability on single random variables and probability distributions

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Identify** the fundamental concepts of analyticity and differentiability for finding complex conjugates , conformal mapping of complex transformations.	Apply
CO 2	**Apply** integral theorems of complex analysis and its consequences for the analytic function with derivatives of all orders in simple connected region.	Apply
CO 3	**Extend** the Taylor and Laurent series for expressing the function in terms of complex power series.	Apply
CO 4	**Apply** Residue theorem for computing definite integrals by using the singularities and polesof real and complex analytic functions over closed curves.	Apply
CO 5	**Explain** the concept of random variables and types of random variables by using suitable real time examples.	Understand
CO 6	**Interpret** the parameters of random variate Probability distributions by using their probability functions, expectation and variance.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Build the prototype of UAVs and aero-foil models for testing by using low speed wind tunnel towards research in the area of experimental aerodynamics.	-	-
PSO 2	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	-	-
PSO 3	GMake use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	-	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	-	-	✓		-	-	-	-	-	-		-	-	-
CO 5	✓	-	-	✓	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	-	-	-		-	-	-	-	-	-	-	-	-	

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUT COMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	**PO 1**	Identify the basic properties of analytic functions which are closed with respect to the fundamental operations of arithmetic (knowledge), algebra and applicability in solving majority of functions in various engineering problems by applying Mathematical principles.	2
CO 2	**PO 1**	Apply the integral theorem of complex analysis (knowledge) and its consequences to the analytic function for solving complex problems by applying the principal problems of mathematics.	2
	PO 2	Identify the problem statement to build extensions of Cauchy's theorem and application of necessary condition to vanish a contour integral around the simple connected regions from the provided information and data in reaching substantiated conclusions by using principles of mathematics.	4
	PO 4	Apply quantitative methods to simplify the calculation of certain contour integrals (knowledge) on simply connected regions in order to solve engineering problems.	2
CO 3	**PO 1**	Apply the knowledge of geometric series that enable us to use Cauchy's integral formula for understanding power series representations of analytic functions by applying the principles of mathematics.	2
	PO 2	IdeIdentify the problem formulation and abstraction of rational complex functions for expressing in negative or positive terms of power series (knowledge) using Laurent's series and Taylor's series by applying the principles of mathematics.	4

CO 4	**PO 1**	Apply the method of finding residues of given real or complex integrand (knowledge) the singular points and poles of complex functions and applicability of Residue theorem to solve definite and indefinite complex integrals by applying the principles of mathematics.	2
	PO 4	Make use of the quantitative methods of finding residues for evaluating line integrals (length of curve) of analytic functions over closed curves and applicability of Residue theorem by applying the principles of mathematics.	2
CO 5	**PO 1**	Explain(understanding) the concept of random variables and Calculate the expected values, variances (Application) of the discrete and continuous random variables (knowledge) for making decisions in complex engineering problems under randomized probabilistic conditions by using principles of mathematics.	3
	PO 2	Apply the concepts of discrete and continuous probability distributions which involves the role of Arithmetic mean, median, mode and variance, mathematical functions (principles of mathematics)for solving complex engineering problems under probabilistic conditions	1
CO 6	**PO 1**	Interpret the Probability distributions such as Binomial, Poisson and Normal distribution (Understanding) with the support of evaluation of integrals (principles of mathematics) and appreciate their importance and applicability (Apply) in solving complex engineering problems involving uncertainty.	3

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	**PROGRAM OUTCOMES**												**PSO'S**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	4	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	-	-	2		-	-	-	-	-	-		-	-	-
CO 5	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	-	-	-	-	-	-	-	-	-	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.7	40.0	-	20	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.7	40.0	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.7	-	-	20		-	-	-	-	-	-		-	-	-
CO 5	100	-	-	10	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	-	-	-		-	-	-	-	-	-		-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	4	-	3	-	-	-	-	-	-	-	-	-	-	-
AVERAGE	3	2	-	1	-	-	-	-	-	-	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓PO4	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	Tech-talk	✓	Concept video	✓
Assignments	-				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

x	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**COMPLEX FUNCTIONS AND DIFFERENTIATIONS**
	Complex functions and its representation on argand plane, concepts of limit, continuity, differentiability, analyticity, Cauchy-Riemann conditions and harmonic functions; Milne-Thomson method, Bilinear Transformation
MODULE II	**COMPLEX INTEGRATION**
	Line integral: Evaluation along a path and by indefinite integration; Cauchy's integral theorem; Cauchy's integral formula; Generalized integral formula; Power series expansions of complex functions And contour Integration: Radius of convergence.
MODULE III	**POWER SERIES EXPANSION OF COMPLEX FUNCTION**
	Expansion in Taylor's series, Maclaurin's series and Laurent series. Singular point; Isolated singular point; Pole of order m; Essential singularity; Residue: Cauchy Residue Theorem. Evaluation of Residue by Laurent Series and Residue Theorem. Evaluation of integrals of the type $\int_0^{2\pi} f(\cos\theta, \sin\theta) d\theta$ and $\int_0^{\infty} f(x)dx$
MODULE IV	**SINGLE RANDOM VARIABLES**
	Random variables: Discrete and continuous, probability distributions, mass function-density function of a probability distribution. Mathematical expectation. Moment about origin, central moments, moment generating function of probability distribution.
MODULE V	**PROBABILITY DISTRIBUTIONS**
	Binomial, Poisson and normal distributions and their properties.

TEXTBOOKS

1. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley and Sons Publishers, 10th Edition,2010

2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 43rd Edition, 2015.

REFERENCE BOOKS:

1. T.K.V Iyengar, B. Krishna Gandhi, "Engineering Mathematics - III", S. Chand and Co., 12th Edition, 2015.

2. Churchill, R.V. and Brown, J.W, "Complex Variables and Applications", Tata Mc Graw-Hill, 8th Edition, 2012.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112105171/1

COURSE WEB PAGE:

1. lms.iare.ac.in

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Course Objectives, Course Outcomes, Program Outcomes, Co-PO Mapping		
CONTENT DELIVERY (THEORY)			
2	Understanding the complex function in Argand plane	CO 1	T1:12.4, R1:4.13
3	Apply the limit of a complex function	CO 1	T1:12.4, R1:4.13
4	Apply the continuity of a complex function	CO 1	T1:12.4, R1:4.13
5	Apply the differentiability and analyticity of a complex function	CO 1	T1:12.4, R1:4.13
6	Identify and Apply the of Cauchy-Riemann conditions in Cartesian and Polar forms	CO 1	T1:12.4, R1:4.13
7	Evaluate the Harmonic Conjugates	CO 1	T1:12.4, R1:4.13
8	Apply the Milne-Thomson method to find the Analytic function	CO 1	T1:12.4, R1:4.13
9	Apply the properties of Bilinear transformation for complex functions.	CO 1	T1:12.5, R1:8.8
10	Evaluate the Line Integral for a given path	CO 2	T1:13.1, R1:5.3
11	Apply the Cauchy's integral theorem in a given plane	CO 3	T1:13.1, R1:5.3
12	Apply the Cauchy's integral formula for evaluating contour integration	CO 3	T1:13.1, R1:5.3
. 13	Apply the Cauchy's general integral formula for evaluating contour integration.	CO 3	T1:13.1, R1:5.3
14	Define the Power series expansions of complex functions and contour Integration	CO 4	T1:14.1, R1:6.1
15	Evaluate the Radius of convergence of power series complex function	CO 4	T1:14.1, R1:6.1
16	Identify the types of power series expansions	CO 4	T1:14.1, R1:6.1
17	Define the types of Singularities and its nature	CO 4	T1:15.2 , R1:6.6
18	Define the concept of Residues	CO 4	T1:15.2 , R1:6.6

19	Evaluate the Residues of complex functions.	CO4	T1:15.2 , R1:6.6
20	Evaluate of contour integrals by Residue theorem.	CO4	T1:15.2 , R1:6.6
21	Establish the basic concepts of Random variables	CO 5	T2: 7.14, R1:1.6
22	Analyze the types of Probability distributions	CO5	T2: 7.14, R1:1.6
23	Discuss the Mass function, Density function	CO5	T2: 7.14, R1:1.6
24	Asses the Expectations of Probability Distribution	CO5	T2: 7.14, R1:1.6
25	Discuss and Estimate the Moment and Central moments	CO 5	T2: 16.6, R1:7.36
26	Discuss and Estimate the Moment Generating functions	CO 5	T2: 16.8, R1:7.41
27	Analyze and Apply the parameters	CO 5	T2: 16.9, R1:7.42
28	Analyze and Apply the Poisson Distribution parameters	CO 6	T2: 16.9, R1:7.42
29	Analyze and Apply the Normal Distribution parameters	CO 6	T2: 16.9, R1:7.42
30	Complex functions differentiation and integration: Complex functions and its representation on argand plane	CO 2	T2: 16.9, R1:7.42
31	Concepts of limit, continuity	CO 1	T1:12.4, R1:4.13
32	Establish the basic concepts of Random variables	CO5	T2: 7.14 R1:1.6
33	Analyze the types of Probability distributions	CO5	T2: 7.15 R1:16.5
34	Discuss the Mass function, Density function	CO8, CO9	T2:11.3 R1:16.5
35	Asses the Expectations of Probability Distribution	CO5	T2: 16.5 R1:7.32
36	Discuss and Estimate the Moment and Central moments	CO 5	T2: 16.6 R1:16.9
37	Discuss and Estimate the Moment Generating functions	CO 5	T2: 11.4 R1:16.18
38	Analyze and Apply the Binomial Distribution parameters	CO6	T2: 16.8 R1:7.41

39	Analyze and Apply the Poisson Distribution parameters	CO 6	T1:17.5-17.6, R1:16.3.1
40	Analyze and Apply the Normal Distribution parameters	CO 6	T2: 16.9, R1:7.422 ,
41	Problems on integral formula	CO 4	T1:13.4, R1:5.10
PROBLEM SOLVING/ CASE STUDIES			
42	Problems on generalized integral formula	CO 2	T1:14.1, R1:6.1
43	Problems on generalized integral formula	CO 2	T1:14.1, R1:6.1
44	Problems on power series expansions of complex functions Expansion in Taylor's series	CO 3	T1:14.1, R1:6.1
45	Problems on Maclaurin's series	CO 3	T1:15.2 , R1:6.6
46	Problems on Laurent series	CO 3	T1:15.3, R1:7.9
47	Problems on types of singularities , pole of order m	CO 4	T1:15.3, R1:7.9
48	Problems on evaluation of residue by Laurent Series	CO 3	T1:15.3, R1:7.9
49	Problems on Residue Theorem.	CO 4	T1:14.1, R1:6.1
50	Problems on definite integrals of the type -I	CO 3	T1:15.3, R1:7.9
51	Problems on indefinite integrals of type-II	CO 4	T1:15.3, R1:7.9
52	Problems on Binomial Distribution	CO 6	T2: 16.9, R1:7.42
53	Problems on Poisson Distribution	CO 6	T2: 16.9, R1:7.42
54	Problems on Normal Distribution	CO 6	T2: 16.9, R1:7.42
55	Problems on Moment Generating functions	CO 5	T2: 16.7, R1:7.36
56	Definitions and terminology Cauchy-Riemann conditions in Cartesian and Polar forms	CO 1,CO2	T1:12.4, R1:4.13
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Definitions and terminology the differentiability and analyticity of a complex function	CO 1,CO2	T1:12.4, R1:4.13
58	Definitions and terminology Milne-Thomson method to find the Analytic function	CO 1,CO2	T1:12.4, R1:4.13
59	Definitions and terminology on Cauchy's general integral formula for evaluating contour integration, on types of singularities , pole of order m	CO 4	T1:13.4, R1:5.10

60	Definitions and terminology on probabilities.	CO 5	T1:15.2 , R1:6.6
61	Definitions and terminology on distributions	CO 6	T1:12.4, R1:4.13
DISCUSSION OF QUESTION BANK			
62	Discussion of Question Bank of Module II Complex functions and differentiation	CO 1	T1:12.3, R1:4.4
63	Discussion of Question Bank of Module II complex integration	CO 2	T1:12.5, R1:8.8
64	Discussion of Question Bank of Module III power series expansion of complex function	CO3,CO 4	T1:15.1, R1:7.4
65	Discussion of Question Bank of Module IV Random variables	CO 5	T2: 7.15, R1:1.65
66	Discussion of Question Bank of Module V Probability distributions	CO 6	T2: 16.9, R1:7.42

Course Coordinator: **HOD, EEE**
Ms B Praveena , Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
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Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**AC MACHINES LABORATORY**				
Course Code	AEE106				
Program	B.Tech				
Semester	IV				
Course Type	Core				
Regulation	R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Mr. K Devender Reddy, Assistant Professor				

I COURSE PRE-REQUISITES AND CO-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE004	III	DC Machines and Transformers
B.Tech	AEE007	IV	AC Machines

II COURSE OVERVIEW:

This course is intended to train the students on alternating current machines. It provides hands-on experience by conducting various direct and indirect tests on transformers, synchronous and asynchronous machines to analyse the characteristics of AC machines and separate various losses. This course also enables to develop skills to select, install, operate, and maintain various types of AC machines and transformers

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
AC Machines Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner,

both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

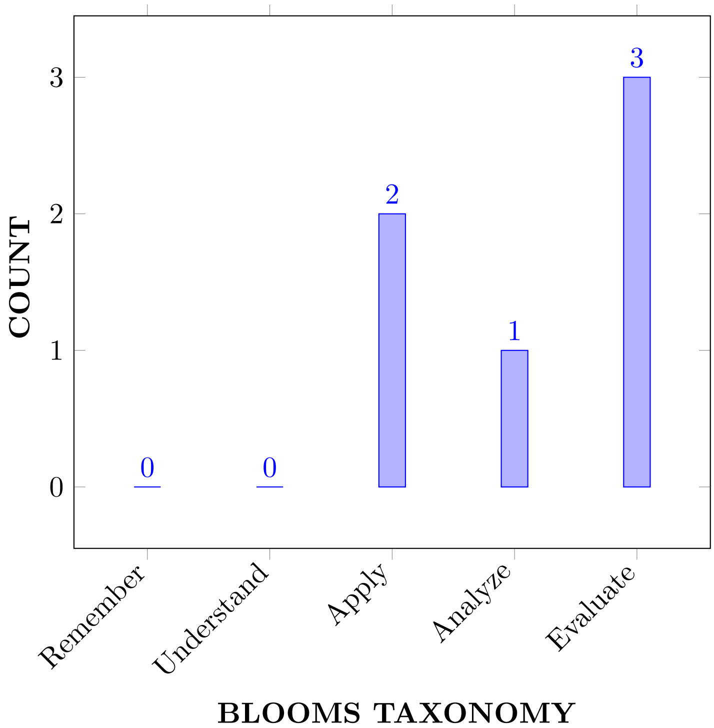
I	The elementary experimental and modelling skills for handling problems with electrical machines in industries and domestic applications.
II	The operation of AC machines and its role in power transmission and generating stations.
III	The automation concepts through programmable logic controllers to control the speed and starting current.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Select** suitable testing strategies for evaluating the performance characteristics of transformers.	Apply
CO 2	**Determine** the performance parameters of induction motor by conducting direct and indirect tests.	Evaluate
CO 3	**Explain** the parallel operation of alternators for load sharing under various loading conditions.	Evaluate
CO 4	**Distinguish** the synchronous impedance and ampere turns methods for the computation of voltage regulation of an alternator.	Analyze
CO 5	**Estimate** the voltage and current swings in salient pole alternator for determination of direct and quadrature axis reactance.	Evaluate
CO 6	**Apply** programmable logic controllers for limiting the starting current of poly phase induction motors.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	3	Lab Exercise
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3	Lab Exercise
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	Lab Exercise
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	Lab Exercises
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	Lab Exercises
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	2	Lab Exercises
PO 9	Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Lab Exercise
PO 10	**Communication:** Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	2	Lab Exercises

PO 12	Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	Lab Exercise

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.	3	Lab Exercises
PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

Course Outcomes	**PO'S, PSO'S**	**Justification for mapping (Students will be able to)**	**No. of Key competencies**
CO 1	PO 1	Understand the performance characteristics of transformer using **principles of Mathematics and Engineering**	2
	PO 2	Solve the complex problems related to efficiency and characteristics of transformers and validate their specifications with **basics principles of mathematics and engineering sciences**.	7
	PO 3	Demonstrate the single phase transformer characteristics **for design solutions of complex engineering problems**	7
	PO 4	Understand the working of transformers using mathematical model under loaded and unloaded conditions **with analysis and interpretation of data**	9
	PO 6	Illustrate the working of transformers using mathematical model under loaded and unloaded conditions **for safety issues in professional engineering practice**	3
	PO 8	Understand the working of transformers using mathematical model under loaded and unloaded conditions **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte working of transformers using mathematical model under loaded and unloaded conditions **to function effectively as an individual and as a member in team**	6

	PO 10	**Communicate** effectively on **complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and**write effective reports** and **design documentation**, make effective presentation and give and receive clear instructions.	3
	PO 12	Understand the working of transformer using mathematical model under loaded and unloaded conditions **in life long learning in technological change**	4
	PSO 1	Understand different transformer connections in **Power transmission**	2
	PSO 3	Illustrate the working of transformers using mathematical model under loaded and unloaded conditions **in automation process using PLC and process controllers**	5
CO 2	PO 1	Understand the performance characteristics of poly phase induction motors and determine equivalent circuit parameters by applying the principles of **mathematics, science to the solutions of complex engineering problems**.	2
	PO 2	Solve the **complex engineering problems** related to efficiency and characteristics of induction motors and **validate** their specifications with **basics principles of mathematics and engineering sciences**.	4
	PO 3	Demonstrate the poly phase induction motor characteristics **for design solutions of complex engineering problems**	7
	PO 4	Understand the working of three phase induction motor using mathematical model under loaded and unloaded conditions **with analysis and interpretation of data**	9
	PO 6	Illustrate the working of three phase induction motor using mathematical model under loaded and unloaded conditions **for safety issues in professional engineering practice**	3
	PO 8	Understand the working of three phase induction motor using mathematical model under loaded and unloaded conditions **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance winding factors.	3
	PO 10	**Communicate** effectively on **complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and**write effective reports** and **design documentation**, make effective presentation and give and receive clear instructions .	3
	PO 12	Understand the working of induction machines using mathematical model under loaded and unloaded conditions **in life long learning in technological change**	4

	PSO 1	Understand different function of different types of induction motors in **Power utilization**	2
	PSO 3	Illustrate the working of induction machines using mathematical model under loaded and unloaded conditions **in automation process using PLC and process controllers**	7
CO 3	PO 1	Apply the **(knowledge)** of load characteristics for the parallel operation of alternator by analyzing **complex engineering problems** using the principles of **mathematics, engineering science.**	2
	PO 2	Understand the load sharing capabilities and reliability of alternators using parallel operation under various loading conditions with**problem statement by analyzing complex engineering problems.**	7
	PO 3	Develop the load sharing capabilities and reliability of synchronous generators using parallel operation under various loading conditions **for design solutions of complex engineering problems**	7
	PO 4	Understand thethe load sharing capabilities and reliability of alternators using parallel operation under various loading conditions **with analysis and interpretation of data**	9
	PO 6	Illustrate the load sharing capabilities and reliability of AC generators using parallel operation under various loading conditions **for safety issues in professional engineering practice**	3
	PO 8	Understand the load sharing capabilities and reliability of AC generators using parallel operation under various loading conditions **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the the load sharing capabilities and reliability of synchronous generators using parallel operation under various loading conditions **to function effectively as an individual and as a member in team**	6
	PO 10	**Communicate** effectively on **complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and**write effective reports** and **design documentation**, make effective presentation and give and receive clear instructions .	3
	PO 12	Understand the load sharing capabilities and reliability of AC generators using parallel operation under various loading conditions **in life long learning in technological change**	4
	PSO 1	Demonstrate the the load sharing capabilities and reliability of AC generators using parallel operation under various loading conditions **in power genration**	4

	PSO 3	Illustrate the load sharing capabilities and reliability of AC generators using parallel operation under various loading conditions **in automation process using PLC and process controllers**	7
CO 4	PO 1	Apply the **(knowledge)** of no load and load characteristics for computing voltage regulation by analyzing **complex engineering problems** using the principles of **mathematics, engineering science.**	2
	PO 2	Demonstrate synchronous impedance and ampere turns methods and apply these methods for **problem formulation** to determine the voltage regulation using **basic principles of mathematics.**	7
	PO 3	Demonstrate the synchronous impedance and ampere turns methods **for design solutions of complex engineering problems**	7
	PO 4	Understand the voltage regulation calculations by graphical methods **with analysis and interpretation of data**	9
	PO 6	Illustrate the synchronous impedance and ampere turns methods **for safety issues in professional engineering practice**	3
	PO 8	Understand the voltage regulation calculation methods **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the voltage regulation calculation methods **to function effectively as an individual and as a member in team**	6
	PO 10	**Communicate** effectively on **complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and**write effective reports** and **design documentation**, make effective presentation and give and receive clear instructions .	3
	PO 12	Understand the synchronous impedence and ampere turns methods for **in life long learning in technological change**	4
	PSO 1	Demonstrate the voltage regulation calculations **in power genration**	4
	PSO 3	Illustrate the synchronous impedence and ampere turns methods of AC generators **in automation process using PLC and process controllers**	5
CO 5	PO 1	Understand the voltage and current swings in salient pole alternator using **principles of Mathematics and Engineering**	2
	PO 2	Analyze the phasor diagram of salient pole synchronous machine to understand mathematical equations of direct and quadrature axis components and validate their specifications with basic principles of mathematics and engineering science	7

	PO 3	Demonstrate the slip test **for design solutions of complex engineering problems**	7
	PO 4	Understand the direct axis and quadrature axis reactance calculations **with analysis and interpretation of data**	9
	PO 6	Illustrate the voltage and current swings in salient pole alternators **for safety issues in professional engineering practice**	3
	PO 8	Understand the direct and quadrature axis reactance calculations **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance of voltage and current swings in synchronous motor	3
	PO 10	**Communicate** effectively on **complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and**write effective reports** and **design documentation**, make effective presentation and give and receive clear instructions.	3
	PSO 1	Illustrate the effect of voltage and current swings on power generation and its effect on inter connected devices in **power system.**	2
	PSO 3	Illustrate the voltage and current swings of synchronous motors **in automation process using PLC and process controllers**	5
CO 6	PO 1	Understand the starting methods of poly phase induction motor using **principles of Mathematics and Engineering**	2
	PO 2	Analyze the starting methods of poly phase induction motor using programmable logic controllers and validate their specifications with basic principles of mathematics and engineering science	7
	PO 3	Demonstrate programmable logic controllers for limiting the starting current **for design solutions of complex engineering problems**	7
	PO 4	Understand the programmable logic controllers application for limiting starting current **with analysis and interpretation of data**	9
	PO 5	Create, select, and apply appropriate techniques, resources, and **modern Engineering tools** for starting and speed control of poly phase induction motors using programmable logic controllers to complex Engineering activities with an understanding of the limitations.	1
	PO 6	Illustrate the function of PLCs for limiting starting current of three phase induction motors**for safety issues in professional engineering practice**	3

	PO 8	Understand the function of PLCs for limiting starting current of three phase induction motors **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance PLCs in limiting the starting current in three phase induction motor	6
	PO 10	**Communicate** effectively on **complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and**write effective reports** and **design documentation**, make effective presentation and give and receive clear instructions .	3
	PSO 1	Illustrate the function of PLCs for limiting the starting current in three phase induction motor **power system.**	4
	PSO 3	Design the different control circuits using programmable logic controller and different tools necessary for entry level position to meet the Requirements of the Employer	7

XII MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	3	3	-	2	-	3	3	3	-	2	3	0	2
CO 2	3	3	3	3	-	2	-	3	3	3	-	2	3	0	3
CO 3	3	3	3	3	-	2	-	3	3	3	-	2	3	0	3
CO 4	3	3	3	3	-	2	-	3	3	3	-	2	3	0	2
CO 5	3	3	3	3	-	2	-	3	3	3	-	2	3	0	2
CO 6	3	3	3	3	3	2	-	3	3	3	-	2	3	0	3

XIII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIV ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XV SYLLABUS:

WEEK I	**OC AND SC TEST ON SINGLE PHASE TRANSFORMER**
	Determine the equivalent circuit parameters; predetermine the efficiency and regulation by open circuit and short circuit test on a single phase transformer.
WEEK II	**SUMPNER'S TEST**
	Predetermine the efficiency and regulation of two identical single phase transformers
WEEK III	**SCOTT CONNECTION OF TRANSFORMERS**
	Conversion of three phase to two phase using single phase transformers.
WEEK IV	**SEPARATION OF CORE LOSSES IN SINGLE PHASE TRANSFORMER**
	Find out the eddy current and hysteresis losses in single phase transformer.
WEEK V	**HEAT RUN TEST ON SINGLE PHASE TRANSFORMERS**
	Determine the temperature rise in three single phase transformers set.
WEEK VI	**BRAKE TEST ON THREE PHASE SQUIRREL CAGE INDUCTION MOTOR**
	Plot the performance characteristics of three phase induction motor.
WEEK VII	**CIRCLE DIAGRAM OF THREE PHASE SQUIRREL CAGE INDUCTION MOTOR**
	Plot the circle diagram and predetermine the efficiency and losses of three phase squirrel cage induction motor.
WEEK VIII	**REGULATION OF ALTERNATOR BY EMF METHOD**
	Determine the regulation of alternator using synchronous impedance method.
WEEK IX	**SLIP TEST ON THREE PHASE SALIENT POLE SYNCHRONOUS MOTOR**
	Determination of Xd and Xq in a three phase salient pole synchronous motor.
WEEK X	**V AND INVERTED V CURVES OF SYNCHRONOUS MOTOR**
	Plot V and inverted V curves to study the effect of power factor in synchronous motor.
WEEK XI	**EQUIVALENT CIRCUIT PARAMETERS OF SINGLE PHASE INDUCTION MOTOR**
	Determine the equivalent circuit parameters of a single phase induction motor.
WEEK XII	**OC AND SC TESTS ON SINGLE PHASE TRANSFORMER USING DIGITAL SIMULATION**
	Determine the efficiency and regulation by open circuit and short circuit test in a single phase transformer using digital simulation.
WEEK XIII	**SCOTT CONNECTION OF TRANSFORMERS USING DIGITAL SIMULATION**
	Scott connection of single phase transformers using digital simulation
WEEK XIV	**STAR – DELTA STARTER OF INDUCTION MOTOR USING PLC**
	Implementation of star-delta starter using PLC.

TEXTBOOKS

1. P S Bimbhra, "Electrical Machinery", Khanna Publishers, 1^{st} Edition, 2011.
2. J B Guptha "Theory and performance of Electrical machines", S.K.Kataria and Sons Publishers 14^{th} Edition, 2009.

3. I J Nagrath and D P Kothari, "Electric Machines", McGraw Hill Education, 1st Edition, 2010.

REFERENCE BOOKS:

1. M G Say, E O Taylor, "Direct Current Machines", Longman Higher Education, 1st Edition, 2002.
2. A E Fitzgerald and C Kingsley, "Electric Machinery", New York, McGraw Hill Education, 1st Edition, 2013

XVI COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	OC and SC test on single phase transformer.	CO 1	T2:1.21
2	Sumpner's test.	CO 1	T2:2.10
3	Heat run test on single phase transformers	CO 1	T2:1.19
4	Scott connection of transformers	CO 1	T2:2.5
5	Separation of core losses in single phase transformer.	CO 1	T2.1.19
6	Brake test on three phase squirrel cage induction motor.	CO 2	T2:7.29
7	Circle diagram of three phase squirrel cage induction motor	CO 2	T2:7.31
8	Regulation of alternator by EMF method.	CO 4	T2:3.17
9	Slip test on three phase salient pole synchronous motor.	CO 5	T2:5.11
10	V and inverted v curves of synchronous motor.	CO 4	T2:5.13
11	Equivalent circuit parameters of single phase induction motor.	CO 2	T2:10.7
12	OC and SC tests on single phase transformer using digital simulation	CO 1	T2:2.3
13	Scott connection of transformers using digital simulation	CO 1	T2:2.3
14	Implementation of star-delta starter using PLC.	CO 6	T2:8.2

XVII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design two phase to three phase conversion system using single phase transformers.
2	Design parallel operation of alternators with synchro scope.
3	Design speed control of induction motor using digital simulation.
4	Design back-to-back connection of identical single phase transformers using digital simulation.
5	Design zero power factor method for calculating voltage regulation.

Signature of Course Coordinator **HOD, EEE**
Mr. K Devender Reddy, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRONICS ENGINEERING
COURSE DESCRIPTION

Course Title	**Electrical Measurements and Instrumentation Laboratory**				
Course Code	AEE107				
Program	B.Tech				
Semester	IV	EEE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Dr. M Laxmidevi Ramamaniah, Associate Professor				

I COURSE OVERVIEW:

The objective of this laboratory course is to learn about the electrical measurement methods, operational principles with suitable software and hardware. It provides an opportunity for the students to identify and calibrate the various electrical instruments for obtaining errors. The lab emphasizes on the practical skills to design and realize the use of instruments for different electrical applications..

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE104	III	DC Machines Laboratory
B.Tech	AEE105	III	Electrical Engineering Simulation Laboratory

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electrical Measurements and Instrumentation Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

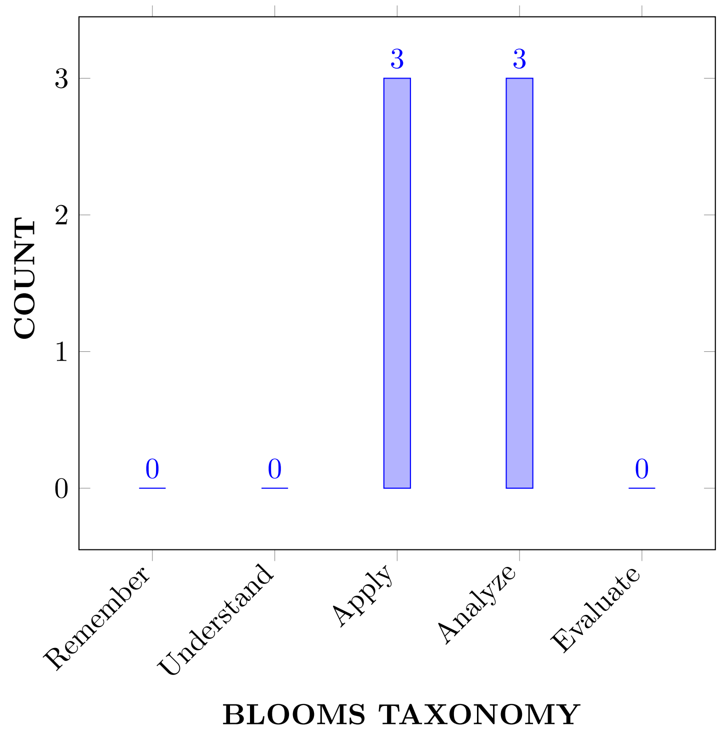
I	The calibration and testing methods of different electrical measuring instruments used for the measurement of voltage, current, power, energy.
II	The different transducers for measurement of physical quantities like pressure, temperature, level.
III	The simulation models in Labview to measure passive electrical parameters.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Make use of** transducers like thermocouple, thermistorand resistance temperature detector for measuring temperature.	Apply
CO 2	**Choose** appropriate transducers for the measurement of strain, pressure, position and level.	Apply
CO 3	**Examine** the errors in measuring instrument by calibrating voltmeter, ammeter, LPF wattmeter, single phase energy meter,dynamometer power factor meter.	Analyze
CO 4	**Develop** Labview programs for displaying electrical waveforms and Lissajous patterns .	Analyze
CO 5	**Build** simulation models in digital environment forthe measurement of passive parameters like inductance, capacitance and resistance.	Apply
CO 6	**Analyze** the quantities like turns ratio, reactive power, errors associated with current transformer for reducing the errors in measuring instruments.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises
PO 2	**Problem analysis::** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Lab Exercises
PO 3	**Design/development of solutions:** : Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	Lab Exercises
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Lab Exercises
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	Lab Exercises
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	2	Lab Exercises
PO 9	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Lab Exercises
PO 12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	1	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	1	Lab Exercises
PSO 3	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Recall the instruments used for measuring physical parameters using the **knowledge of mathematics, science, and engineering fundamentals.**	3
	PO 8	Understand the performance characteristics of PMMC, MI instruments **with ethical principles, professional ethics and responsibilities**	2
	PO 9	**Develop** the attitude to get along with each other to function effectively.	2
	PO 10	**Make use of** oral, written and visual means to critique, negotiate, create and communicate understanding	2
	PO 12	**Recognize the need for** the importance of temperature in measuring devices to calibrate at specific temperature.	1
	PSO 3	Illustrate the operation of transducer applications **in automation process**	3
CO 2	PO 1	**Recall** the working of transducers with the help of **fundamentals of science and engineering fundamentals.**	2
	PO 2	**Understand** the operation of various instruments **with problem statement by analyzing complex engineering problems.**	2
	PO 3	**Design** solutions for measurement of physical parameters with economic perspective.	2
	PO 4	**Make use of** engineering knowledge of different transducers to solve engineering problems.	2

	PO 8	**Make use of** engineering knowledge of different transducers to solve engineering problems.	2
	PO 9	**Identify** and define an appropriate team negotiates solutions, ideas, roles and responsibilities.	2
	PO 10	**Use** communication as a tool for clarity	1
	PO 12	**Develop** significant skills and find learning resources to develop a Lab VIEW application.	1
	PSO 3	Illustrate the operation of transducer applications **in automation process**	3
CO 3	PO 1	Recall the basic electrical parameters with the help of **fundamentals of mathematics, science, and engineering fundamentals.**	1
	PO 2	Recall the basic electrical parameters with the help of **fundamentals of mathematics, science, and engineering fundamentals.**	2
	PO 3	**Understand customer and user needs of** power and energy requirements and understand economic context of engineering processes.	3
	PO 4	**Recognize (Knowledge) the characteristics of** wattmeter, ammeter, power factor meter with appropriate codes of practice and apply to analyse key engineering processes in laboratory	3
	PO 8	**Recognize (Knowledge) the characteristics of** wattmeter, ammeter, power factor meter with appropriate codes of practice and apply to analyse key engineering processes in laboratory	2
	PO 9	**Develop** ability to Work well with a team and get along with others.	3
	PO 10	**Make use of** communication as a tool helps in negotiating and creating new understanding, interacting with others, and furthering their own learning	3
	PO 12	**Identify** new technology in measuring electrical parameters	1
	PSO 1	Quantify the errors in power systems to ensure **efficient operation of electrical system.**	1
	PSO 3	Illustrate the operation of voltmeter, ammeter applications **in automation process**	3
CO 4	PO 1	Recall the electrical parameters using the **engineering scientific principles and methodology.**	2
	PO 2	**Identify** the phase and frequency of waveforms using Lissajous patterns.	2
	PO 3	**Use** LabVIEW for engineering activities to establish innovative solutions	2

	PO 4	**Develop** laboratory skills of simulation models and computer software relevant to engineering disciplines	2
	PO 5	**Develop** simulation program in **Labview software** to analyse voltage and current waveforms, Lissajous patterns	3
	PO 8	**Use** LabVIEW for engineering activities to establish innovative solutions	2
	PO 9	**Use** LabVIEW for engineering activities to establish innovative solutions	3
	PO 10	**Share** knowledge and skills with colleagues using oral, written, and visual communication to further their own learning	3
	PO 12	**Identify** significant skills for advanced engineering concepts.	2
	PSO 3	Illustrate the operation of LabVIEW applications **in automation process**	3
CO 5	PO 1	**Recall** the electrical parameters using the **engineering scientific principles and methodology.**	2
	PO 2	**Understand** the purpose of using bridges and **identify and apply the information** to measure inductance and capacitance.	3
	PO 3	**Use** LabVIEW for engineering activities to establish innovative solutions	2
	PO 4	**Develop** laboratory skills of simulation models and computer software relevant to engineering disciplines.	2
	PO 5	**Develop** Labview program **in Labview software** to measure passive parameters	3
	PO 8	**Develop** Labview program **in Labview software** to measure passive parameters	2
	PO 9	**Develop** ability to Work well with a team and get along with others.	3
	PO 10	Share knowledge and skills with colleagues using oral, written, and visual communication to further their own learning.	3
	PO 12	**Identify** significant skills for advanced engineering concepts	2
	PSO 3	Illustrate the operation of ac and dc bridge applications **in automation process**	3
CO 6	PO 1	**Remember** the measuring principles of reactive power, turns ratio etc., using the **principles of mathematics and engineering science.**	3
	PO 2	**Identify** the problem of power system and analyze it to select a particular method **using the principles of engineering.**	1

	PO 3	**Develop** solutions to reduce errors in instrument transformers	1
	PO 4	**Develop** laboratory skills to work with technical uncertainty to solve engineering problems.	1
	PO 8	**Develop** laboratory skills to work with technical uncertainty to solve engineering problems.	2
	PO 9	**Experiment with** hands-on labs enable the students to complete the assignments	3
	PO 10	**Demonstrate** the ability to communicate effectively in writing and orally	3
	PO 12	**Identify** industry trends/ new technology relevant to instrument transformers.	1
	PSO 1	**Interface** current transformer **for protection in power system.**	3
	PSO 3	Illustrate the operation of wattmeter applications **in automation process**	3

XII MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	2	3	3	-	1	-	-	3
CO 2	2	2	2	2	-	-	-	2	3	3	-	1	-	-	3
CO 3	1	2	3	3	-	-	-	2	3	3	-	1	1	-	3
CO 4	2	2	2	2	3	-	-	2	3	3	-	2	-	-	3
CO 5	2	3	2	2	3	-	-	2	3	3	-	2	-	-	3
CO 6	3	1	1	1	-	-	-	2	3	3	-	1	1	-	3

XIII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIV ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XV SYLLABUS:

WEEK I	**SENSING OF TEMPERATURE AND SPEED**
	Measurement of temperature using transducers like thermocouple, thermistors and resistance temperature detector with signal conditioning; speed measurement using proximity sensor.
WEEK II	**CALCULATION OF DISTANCE AND LEVEL**
	Distance measurement using ultrasonic transducer, measurement of level using capacitive transduce.
WEEK III	**MEASUREMENT OF STRAIN AND PRESSURE**
	Strain measurement using strain gauge; measurement of pressure using differential pressure transducer.
WEEK IV	**MEASUREMENT OF POSITION AND LINEAR DISPLACEMENT**
	Measurement of position using encoders and measurement of linear displacement using Linear Voltage Differential Transformer (LVDT).
WEEK V	**PHANTOM LOADING ON LPF WATTMETER**
	Calibration of electrodynamometer type LPF wattmeter using phantom loading.
WEEK VI	**CALIBRATION OF SINGLE PHASE ENERGY METER AND POWER FACTOR METER**
	Calibration of single phase energy meter using resistive load and dynamometer power factor meter.
WEEK VII	**MEASUREMENT OF TURNS RATIO AND APPLICATIONS OF CTs**
	Measurement of turns ratio using AC bridge; the extension of range of wattmeter to measure three phase power using two CTs and one single phase wattmeter.
WEEK VIII	**MEASUREMENT OF REACTIVE POWER**
	Measurement of reactive power using one single phase wattmeter
WEEK IX	**NET METERING**
	Study of bidirectional energy measurement using net metering.
WEEK X	**MEASUREMENT OF FREQUENCY AND THD USING DIGITAL SIMULATION**
	Determination of frequency and Total Harmonic Distortion THD using LabVIEW.
WEEK XI	**ANALYSIS OF WAVE FORMS DIGITAL SIMULATION**
	Measurement and display of voltage, current wave forms and analysis using LabVIEW.
WEEK XII	**TWO WATTMETER METHOD USING DIGITAL SIMULATION**
	Measurement of real reactive power using two wattmeter method and verification with LabVIEW.
WEEK XIII	**WORKING OF STATIC ENERGY METER USING DIGITAL SIMULATION**
	Measurement of energy using static energy meter and verification with LabVIEW.
WEEK XIV	**MEASUREMENT OF PASSIVE PARAMETERS USING DIGITAL SIMULATION**

	Resistance measurement using Kelvin's bridge, inductance measurement using Anderson bridge and capacitance measurement using Schering bridge and verification with LabVIEW.

REFERENCE BOOKS:

1. A K Sawhney, —Electrical and Electronic measurement and instruments, Dhanpat Rai and Sons Publications, 2002
2. E W Golding and F C Widdis , Electrical measurements and measuring instruments,Wheeler publishing, 2006
3. D V S Murthy, Transducers and Instrumentation, Prentice Hall of India, London, 2009.

Web references :

1. https://www.gnindia.dronacharya.info/EEEDept/Downloads/Labmanuals/EMI-Lab.pdf
2. https://www.scribd.com/doc/25086994/electrical-measurements-lab

XVI COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Measurement of temperature using transducers like thermocouple, thermistors and resistance temperature detector with signal conditioning; speed measurement using proximity sensor.	CO 1	R3:7.1
2	Distance measurement using ultrasonic transducer; measurement of level using capacitive transducer.	CO 5	R3:6.1
3	Measurement of strain using strain gauge and measurement of pressure using differential pressure transducer.	CO 2	R3:6.1
4	Measurement of position using encoders; measurement of linear displacement using Linear Voltage Differential Transformer (LVDT).	CO 2	R3:6.3
5	Calibration of electrodynamometer type LPF wattmeter using phantom loading.	CO 3	R1:11.6
6	Calibration of single phase energy meter using resistive load and dynamometer power factor meter. .	CO 3	R1:11.6
7	Measurement of turns ratio using AC bridge; the extension of range of wattmeter to measure three phase power using two CTs and one single phase wattmeter.	CO 5	R1:9.7
8	Measurement of reactive power using one single phase wattmeter.	CO 6	R1:10.21
9	Study of bidirectional energy measurement using net metering.	CO 6	R1:9.7
10	Determination of frequency and Total Harmonic Distortion (THD) using LabVIEW.	CO 3	R1:8.5
11	Measurement and display of voltage, current wave forms, frequency Lissajeous patterns and THD using LabVIEW.	CO 4	R1:21.14
12	Measurement of real and reactive powers using two wattmeter method and verification with LabVIEW.	CO 63	R1:10.9

13	Measurement of energy using static energy meter and verification with LabVIEW.	CO 5	R1:11.15
14	Resistance measurement using Kelvins double bridge, inductance measurement using Anderson bridge and capacitance measurement using Schering bridge and verification with LabVIEW.	CO 5	R1:16.5

XVII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Tri-vector meter** Use Tri-vector meter for measuring kW, kVar and kVA of a power line.
2	**MEASUREMENT OF PASSIVE PARAMETERS USING DIGITAL SIMULATION** Measurement of self-inductance by Maxwell's inductance bridge using digital simulation.
3	**MEASUREMENT OF PASSIVE PARAMETERS USING DIGITAL SIMULATION** Measurement of self-inductance by Hay's bridge using digital simulation.
4	**MEASUREMENT OF PASSIVE PARAMETERS USING DIGITAL SIMULATION** Measurement of capacitance by Wein's bridge using digital simulation.
5	**MEASUREMENT OF PASSIVE PARAMETERS USING DIGITAL SIMULATION** Measurement of capacitance by Wein's bridge using digital simulation.

Signature of Course Coordinator **HOD,EEE**
Dr. M Laxmidevi Ramanaiah, Associate Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis**). 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**

PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**

PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**

PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**
PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**
PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer. 1. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTION

Course Title	**Control Systems and Simulation Laboratory**				
Course Code	AEE115				
Program	B.Tech				
Semester	IV	EEE			
Course Type	Core				
Regulation	IARE - R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	K Harshini, Assistant Professor				

I COURSE OVERVIEW:

The Control Systems laboratory course is indeed to train the students practically on the modelling, analysis and design of linear feedback control systems. This course deals with modelling of dynamical systems, and the control components and designing the compensator. The hands on training in the laboratory enable students to apply and modelling control principles in various areas of industrial applications.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSC07	II	Mathematical Transform Techniques
B.Tech	AEEC05	III	Network Analysis
B.Tech	AEEC07	III	DC Machines and Transformers
B.Tech	AEEC12	IV	Control Systems

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Control Systems Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the Principal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

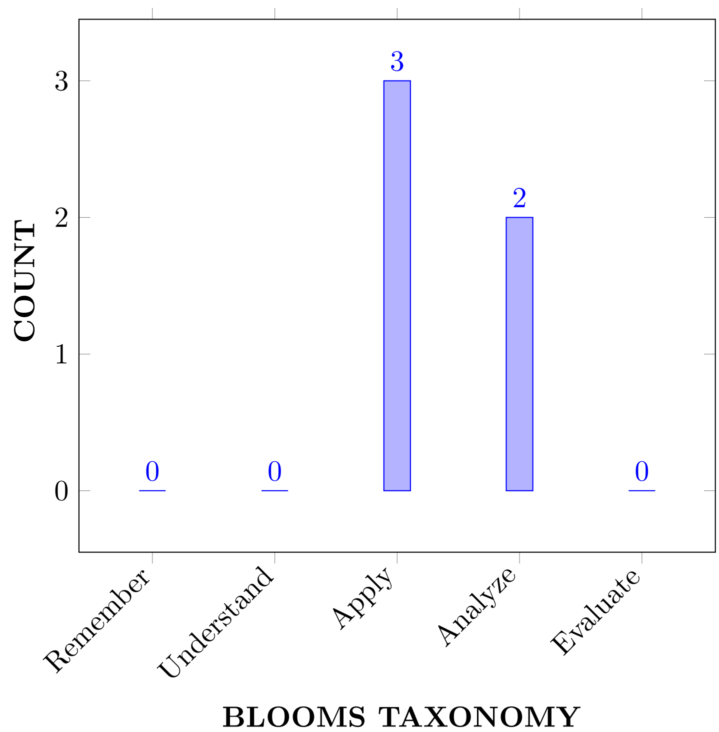
I	The estimation of stability of dynamical systems using Digital simulation.
II	The various techniques of modeling and analysing system's performance.
III	Design the time and frequency response of system by both classical and modern techniques.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Make use of** the knowledge of digital simulation tool for system analysis with different standard inputs .	Apply
CO 2	**Model** the dynamic systems in transfer function using digital simulation tool and validate the performance characteristics of motors.	Apply
CO 3	**Analyse** and select various electronics devices for improving system performance along with tuning mechanism in virtual environment.	Analyse
CO 4	**Experiment** the types of compensation techniques for improving the system's accuracy	Apply
CO 5	**Analyse** the system's stability in time and frequency domain by computing gain and phase margin.	Analyse

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Lab Exercises

PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety,and the cultural, societal, and Environmental considerations	3	Lab exercises
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	Lab Exercises
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	2	Lab Exercises
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Lab Exercises
PO 10	textbfCommunication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	3	Lab Exercises
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.	2	Lab Exercises
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development.	1	Lab Exercises
PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer.	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Understands the standard test signals using the**fundamentals of mathematics, science, and engineering fundamentals**	3
	PO 2	Formulate the standard test signals using the**using first principles of mathematics and engineering sciences**	3
	PO 3	Understand the (**Problem Solving**) for step input at various gain levels and, analysis the data, and using the (complex Engineering problems)	3
	PO 4	Understand the (**research-based knowledge**) step response for second order at various gain levels and, analysis and interpretation of data (provided **synthesis of the information to provide valid conclusions**)	3
	PO 5	Analyse (**computational and experimental tools**) of various dynamic systems into transfer function **for analysing systems performance using digital simulation**	1
	PO 6	Apply the (**knowledge**) to assess societal issues and the consequent responsibilities relevant to the professional engineering practice. **the professional engineering practice.**	2
	PO 8	Apply the (**ethical principles**) to assess second order responses for step input as per the **norms of the engineering practice**	2

	PO 9	Understands the (**Individual and team work**) to assess second order responses for step input as per the **multidisciplinary**and as a member or leader in diverse teams	2
	PO 10	Understands the (**Communication**) effectively on complex engineering activities with the engineering community and with society and design documentation **multidisciplinary**and as a member or leader in diverse teams	2
	PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change Apply (**Life-Long Learning**) recognize the need of it and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2
	PSO 1	Understands (**knowledge**) the basics of various test signals and apply to the RLC network which involves in **transmission and distribution of Electrical Energy**	2
	PSO 2	Understands (**knowledge**) the basics of various test signals and apply to the RLC network which involves in **transmission and distribution of Electrical Energy**	2
CO 2	PO 1	Explain (understand) the characteristics of electrical and mechanical physical systems **using principles of mathematics, science, and engineering fundamentals.**	2
	PO 2	Formulate the (given **problem statement**) the mathematical equations for a governing system (from the provided **framed using basics of mathematics and engineering sciences**) in solving analysis problems.	4
	PO 5	Analyse (**computational and experimental tools**) of various plots in time and frequency domain **for improving the system performance using virtual tools**	1
	PSO 2	Understands (**knowledge**) the working of components in servomotors which **specify the applications of industry and sustainable rural development.**	2
CO 3	PO 1	Summarize (**knowledge**) the characteristics of types of controllers **using principles of mathematics, science, and engineering fundamentals.**	1
	PO 2	Formulate the (given **problem statement**) the mathematical equations for a electronic devices (from the provided **framed using basics of mathematics and engineering sciences**) in solving analysis problems.	4
	PO 5	Analyse (**computational and experimental tools**) of the electronic devices **for improving the system performance using virtual tools**	1

	PSO 2	Understands (knowledge) the characteristics of P, I, D, PID controllers which in solving aircraft analysis problems by applying the **specify the applications of industry and sustainable rural development.**	3
CO 4	PO 1	Understand (knowledge) the characteristics of(apply) types of compensators **using principles of mathematics, science, and engineering fundamentals.**	3
	PO 3	Understand the (**Problem Solving**) for types of compensator s and, analysis the data, and (provided **synthesis of the information to provide valid conclusions**)	3
	PO 5	Analyse (**computational and experimental tools**) of various compensators schemes **for improving the system performance using virtual tools**	1
	PSO 2	Understands (knowledge) the characteristics of compensators which**specify the applications of industry and sustainable rural development.**	3
CO 5	PO 1	Understand the concept of Root Locus, Bode Plots and Nyquist Plot to determine stability using **mathematical principles** basic fundamentals of mathematics science and engineering fundamentals. **engineering fundamentals** of control systems.	2
	PO 2	Determine the **problem statement** stability performance in time and frequency domain transfer function of control system for **interpretation** using basics of mathematics and engineering sciences.	2
	PO 5	Analyse (**computational and experimental tools**) of various plots in time and frequency domain **for improving the system performance using virtual tools**	1

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES											
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2	1	3	2	-	1	2	3	-	1
CO 2	3	2	2	2	2	2	-	1	3	3	-	1
CO 3	3	1	2	2	2	2	-	2	3	3	-	2
CO 4	3	1	2	2	3	2	-	1	2	3	-	1
CO 5	3	1	2	2	3	2	-	2	2	3	-	2

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**TIME RESPONSE OF SECOND ORDER SYSTEM**
	To obtain the time response of a given second order system with time domain specifications.
WEEK II	**TRANSFER FUNCTION OF DC MOTOR**
	Determine the transfer function, time response of DC motor and verification with digital simulation.
WEEK III	**AC SERVO MOTOR**
	Study of AC servomotor and plot its torque speed characteristics.
WEEK IV	**EFFECT OF VARIOUS CONTROLLERS ON SECOND ORDER SYSTEM**
	Study the effect of P, PD, PI and PID controller on closed loop second order systems.
WEEK V	**COMPENSATOR**
	Study lead-lag compensator and obtain its magnitude, phase plots.
WEEK VI	**TEMPERATURE CONTROLLER**
	Study the performance of PID controller used to control the temperature of an oven.
WEEK VII	**DESIGN AND VERIFICATION OF OP-AMP BASED PID CONTROLLER**
	Implementation of op-amp based PID Controller and verification using MATLAB.
WEEK VIII	**STABILITY ANALYSIS USING DIGITAL SIMULATION**
	Stability analysis using root locus, Bode plot, Polar, Nyquist criterions of linear time invariant system by digital simulation.
WEEK IX	**STATE SPACE MODEL USING DIGITAL SIMULATION**
	Verification of state space model from transfer function and transfer function from state space model using digital simulation.
WEEK X	**LADDER DIAGRAMS USING PLC**
	Input output connection, simple programming, ladder diagrams, uploading, running the program and debugging in programmable logic controller.

WEEK XI	**TRUTH TABLES USING PLC**
	Study and verification of truth tables of logic gates, simple boolean expressions and application to speed control of DC motor using programmable logic controller.
WEEK XII	**IMPLEMENTATION OF COUNTER**
	Implementation of counting number of objects and taking action using PLC.
WEEK XIII	**BLINKING LIGHTS USING PLC**
	Implementation of blinking lights with programmable logic controller.
WEEK XIV	**WATER LEVEL CONTROL**
	Control of maximum and minimum level of water in a tank using PLC.

TEXTBOOKS

1. Norman S. Nise, "Control Systems Engineering", John Wiley Sons, Inc., 6th Edition, 2004.
2. J Nagrath, M Gopal, "Control Systems Engineering", New Age International, 3rd Edition,2007.
3. John W. webb, Ronald A.Reis, "Programmable Logic Controllers, Principles and Applications",5th Edition, 2002.
4. A Nagoor Kani, "Control Systems", RBA Publications,1st Edition, 2009.

REFERENCE BOOKS:

1. 1. Benjamin Kuo, "Automatic Control Systems", PHI, 7th Edition, 1987.
2. 2. K Ogata, "Modern Control Engineering", Prentice Hall, 4th Edition, 2003.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Time response of Second Order system.	CO 1	T1:2.1
2	Transfer function of DC motor.	CO 2	T1:3.1
3	Characteristics of Ac Servo Motor	CO 3	T1:3.11
4	Effect of various Controllers on second order systems	CO 4	T1:4.8
5	Compensator.	CO 4	T1:4.8
6	Temperature Controller.	CO 4	T1.5.5
7	Design and verification of Op-Amp Based PID Controller.	CO 4	T1:5.6
8	Stability Analysis Using Digital Simulation.	CO 5	T1:8.3
9	State Space Model Using Digital Simulation.	CO 6	T1:8.3
10	Ladder Diagrams Using PLC.	CO 1	T1:2.1
11	Truth Tables Using PLC	CO 6	T1:8.3
12	Implementation Of Counter Using PLC	CO 2	T1:3.1
13	Blinking Lights Using PLC	CO 2	T1:3.1
14	Water Level Control Using PLC.	CO 5	T1:8.3

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Design the lead compensator using MATLAB:** Modelling of lead compensator using Matlab to study its characteristics .
2	**Controllers using LABVIEW:** Develop the circuits of Controllers for analysing the performance using LABVIEW .
3	**Step Response of system using LABVIEW:** Design various control system circuits using LABVIEW .
4	**Stability Analysis:** Study the stability of a given system by root locus, Bode plot, Nyquist plot using LABVIEW .
5	**Inverted Pendulum:** Study the Inverted Pendulum of DC Motor using LABVIEW on the Quanser Controls Board

Signature of Course Coordinator **HOD,EEE**
K Harshini, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electronics and Communication Engineering**				
Course Title	**Integrated Circuits Applications**				
Course Code	AEC008				
Program	B.Tech				
Semester	V				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	M Sreevani, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEC001	III	Electronic devices and circuits
B.Tech	AEC002	III	Digital system design
B.Tech	AEC006	IV	Pulse and digital circuits

II COURSE OVERVIEW:

This course introduces the fundamental concepts of operational amplifier, linear and non-linear applications of op-amp and digital Integrated circuits. It focus on process of learning about signal condition, signal generation, instrumentation, timing and control using various IC circuits. It provides the knowledge on comparators, digital IC's for combination and sequential circuit designs and the basis for the next level of course VLSI Design.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Integrated Circuits Applications	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into five modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
10%	Understand
65%	Apply
10%	Analyze
0%	Evaluate
0%	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz/ AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc.

VI COURSE OBJECTIVES:

The students will try to learn:

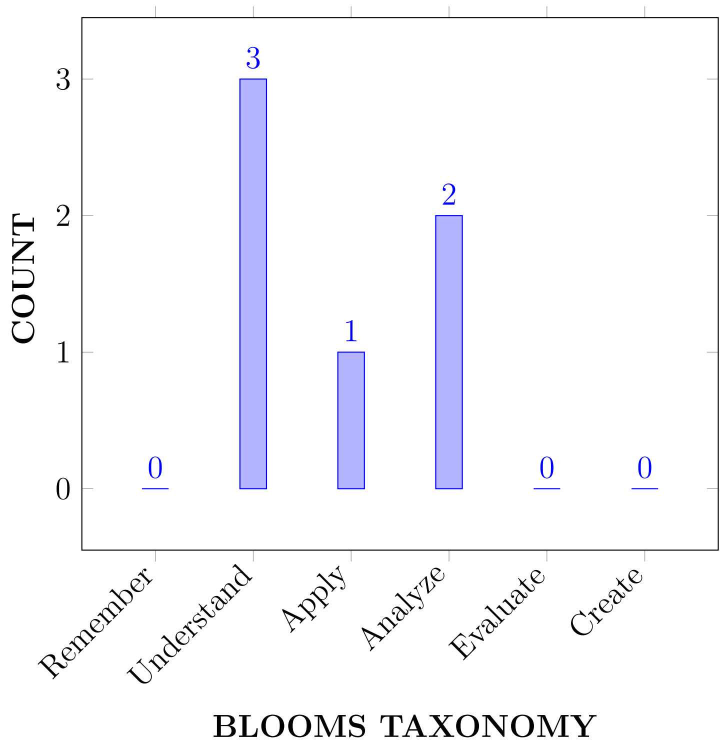
I	The basic building blocks, characteristics and applications of operational amplifier.
II	The functional details of logic families, combinatorial and sequential digital circuits (ICs) used in digital design.
III	Different IC models which are basic for Mixed signal integrated circuits in future.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Describe** the principles and characteristics of op-amp circuits to perform arithmetic operations.	Understand
CO 2	**Distinguish** linear and non-linear applications of op-amp circuits to measure the output characteristics.	Understand
CO 3	**Design** frequency selective circuits using OPAMP for audio and radio frequency ranges.	Analyze
CO 4	**Demonstrate** the characteristics, operation and applications of Multi-vibrators using IC555 timer.	Understand
CO 5	**Choose** an appropriate A/D and D/A converter for signal processing applications.	Apply
CO 6	**Analyze** the characteristics of sequential and combinational digital integrated circuits for digital circuit design.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Program Outcomes	
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.	3	SEE/ CIE/ AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.	3	SEE/ CIE/ AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal and Environmental considerations	1	SEE/ CIE/ AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	SEE/ CIE/ AAT
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	SEE/ CIE/ AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Focus on the Application Specific Integrated Circuit (ASIC) Prototype designs, Virtual Instrumentation and System on Chip (SOC) designs.	2	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	✓	-	-	-	✓	-
CO 3	✓	✓	✓	-	-	-	-	-	-	✓	-	-	-	-	-
CO 4	✓	✓	✓	-	-	-	-	-	-	✓	-	-	-	✓	-
CO 5	✓	✓	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 6	✓	✓	✓	-	-	-	-	-	-	✓	-	-	-	✓	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies matched.
CO 1	PO 1	**Recall** the basic function of transistor , importance of differential amplifier and the characteristics by applying the **own engineering discipline, science principles and methodology.**	2
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems of improving dc, ac characteristics of an operational, **translate the information** into the model from the **provided information and data, develop solutions** as compensation techniques ,**validate** the frequency response , stability of the circuit by the **interpretation of results.**	7
	PO 10	**Speaks orally** on basic of opamp characterstics and internal operations of an operational amplifier.	2
CO 2	PO 1	**Explain** the importance of feedback and realize linear and non linear circuits using op-amp and the application of that model using **own engineering discipline, scientific principles and methodology.**	2
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems of applications of op-amp, **translate the information** into the model using IC741 from the provided **information and data, develop solutions**based on the functionality of the circuit,**validate** the output of the circuit in reaching substantiated conclusions by the **interpretation of results.**	7
	PO 3	**Develop** solution to manage data processing and interfacing applications by **establishing innovative solutions** using data converters .	1
	PO 10	**Speaks fluently** about the importance of feeback and applications of operational amplifier**(Subject matter)**.	2
	PSO 2	**Apply** data converters in the field of application specific integrated circuit (ASIC) prototype designs and system on chip (SOC) designs.	2
CO 3	PO 1	**Explain** the importance of IC 555 timer,voltage regulators and realize multivibrator circuits using IC 555 and the application of that model using **own engineering discipline, scientific principles and methodology.**	2
	PO 2	**Interpret**frequency of oscillations, pulse width and able to change these parameters based on **information and data collection , model translation and validate using experimental design.**	4

Course Outcomes	**PO'S PSO'S**	**Justification for mapping (Students will be able to)**	**No. of Key Competencies matched.**
	PO 3	**Develop** phase locked loop circuit,**based on customer needs for design of** tuners, local oscillator, FM modulators and **evaluate outcomes of the designs.**	2
	PO 10	Understand the given **problem statement** and **formulate** the (complex) engineering problems of improving dc, ac characteristics of an operational, **translate the information** into the model from the **provided information and data, develop solutions** as compensation techniques ,**validate** the frequency response , stability of the circuit by the **interpretation of results.**	2
CO 4	PO 1	**Demonstrate** different data converters for converting analog data to digital data and vice versa **applying basic knowledge of science and engineering fundamentals.**	2
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems of data converters, **translate the information** into the model and prototype systems from the provided **information and data, develop solutions** based on the functionality of the data translation, **validate** the data converters in reaching substantiated conclusions by the **interpretation of results**.	7
	PO 3	**Develop** solution to manage data processing and interfacing applications by **establishing innovative solutions** using data converters .	1
	PO 10	Understand the given **problem statement** and **formulate** the (complex) engineering problems of improving dc, ac characteristics of an operational, **translate the information** into the model from the **provided information and data, develop solutions** as compensation techniques ,**validate** the frequency response , stability of the circuit by the **interpretation of results.**	2
	PSO 2	**Apply** data converters in the field of application specific integrated circuit (ASIC) prototype designs and system on chip (SOC) designs.	2
CO 5	PO 1	**Build** digital logical design using digital ICs with the **knowledge of mathematics, science and engineering fundamentals.**	2
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems of digital system design , **translate the information** into the model and prototype systems from the provided **information and data, develop solutions** digital design using equipment, **validate** the design in reaching substantiated conclusions by the **interpretation of results**.	7

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies matched.
	PO 10	Understand the given **problem statement** and **formulate** the (complex) engineering problems of improving dc, ac characteristics of an operational, **translate the information** into the model from the **provided information and data, develop solutions** as compensation techniques ,**validate** the frequency response , stability of the circuit by the **interpretation of results.**	2
CO 6	PO 1	**Build** digital logical design using digital ICs with the **knowledge of mathematics, science and engineering fundamentals.**	2
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems of digital system design , **translate the information** into the model and prototype systems from the provided **information and data, develop solutions** digital design using equipment, **validate** the design in reaching substantiated conclusions by the **interpretation of results**.	7
	PO 3	**Design** solutions for complex engineering problems such as digital system by doing **innovative solution and implementing them using modern tools.**	3
	PO 10	Understand the given **problem statement** and **formulate** the (complex) engineering problems of improving dc, ac characteristics of an operational, **translate the information** into the model from the **provided information and data, develop solutions** as compensation techniques ,**validate** the frequency response , stability of the circuit by the **interpretation of results.**	2
	PSO 2	**Design** various digital circuits in application secific integrated circuit (ASIC) and system on chip (SOC) designs.	2

Note: For Key Attributes refer **Annexure - I**

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	2	7	-	-	-	-	-	-	-	2	-	-	-	-	-
CO 2	2	7	1	-	-	-	-	-	-	2	-	-	-	2	-
CO 3	2	4	2	-	-	-	-	-	-	2	-	-	-	-	-
CO 4	2	7	1	-	-	-	-	-	-	2	-	-	-	2	-
CO 5	2	7	-	-	-	-	-	-	-	2	-	-	-	-	-
CO 6	2	7	3	-	-	-	-	-	-	2	-	-	-	2	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	66.7	70	-	-	-	-	-	-	-	40	-	-	-	-	-
CO 2	66.7	70	10	-	-	-	-	-	-	40	-	-	-	100	-
CO 3	66.7	40	20	-	-	-	-	-	-	40	-	-	-	-	-
CO 4	66.7	70	10	-	-	-	-	-	-	40	-	-	-	100	-
CO 5	66.7	70	-	-	-	-	-	-	-	40	-	-	-	-	-
CO 6	66.7	70	30	-	-	-	-	-	-	40	-	-	-	100	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 2	3	3	-	-	-	-	-	-	-	1	-	-	-	2	-
CO 3	3	2	1	-	-	-	-	-	-	1	-	-	-	-	-
CO 4	3	3	1	-	-	-	-	-	-	1	-	-	-	2	-
CO 5	3	3	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 6	3	3	1	-	-	-	-	-	-	1	-	-	-	2	-
TOTAL	**18**	**17**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**0**	**0**	**0**	**6**	**0**
AVERAGE	**3**	**2.83**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**2**	**0**

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Quiz	✓	Tech - Talk	-	Certification	-
Term Paper	-	Seminars	-	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	-	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
✓	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts		

XVIII SYLLABUS:

MODULE I	**INTEGRATED CIRCUITS**
	Integrated Circuits: Classification of integrated circuits, Package types and temperature ranges; Differential Amplifier: DC and AC analysis of Dual input Balanced output Configuration; Properties of differential amplifier configuration: Dual Input Unbalanced Output, Single Ended Input, Balanced/ Unbalanced Output; DC Coupling and Cascade Differential Amplifier Stages, Level translator. Characteristics of OP-Amps: Op-amp Block Diagram, ideal and practical Op-amp specifications, DC and AC characteristics, 741 op-amp and its features; Op-Amp parameters and Measurement: Input and Output Off set voltages and currents, slew rate, CMRR, PSRR, and Drift.
MODULE II	**APPLICATIONS OF OPERATIONAL AMPLIFIERS**
	Linear applications of Op- Amps: Inverting and non-inverting amplifier, integrator, differentiator, instrumentation amplifier, AC amplifier; Non-linear applications of Op-Amps: Comparators, multivibrators, triangular and square wave generators, non- linear function generation, log and anti-log amplifiers.
MODULE III	**ACTIVE FILTERS AND TIMERS**
	Active Filters: Classification of filters, 1st order low pass and high pass filters, 2nd order low pass, high pass, band pass, band reject and all pass filters. **Timers:** Introduction to 555 timer, functional diagram, monostable, astable operations and applications, Schmitt Trigger; PLL: Introduction, block schematic, principles and description of individual blocks, 565 PLL.
MODULE IV	**DATA CONVERTERS**
	Data converters: Introduction, classification, need of data converters; DAC techniques: Weighted resistor DAC, R-2R ladder DAC, inverted R-2R DAC, and IC 1408 DAC, DAC characteristics; ADC techniques: Integrating, successive approximation, flash converters, A/D characteristics.
MODULE V	**DIGITAL IC APPLICATIONS**
	Combinational Design Using TTL/ CMOS ICs: Logic delays, TTL/CMOS interfacing, adders, multiplexer, demultiplexer, decoder, encoder; Sequential design using TTL/ CMOS ICs: SR, JK, T, and D flip-flops; Counters: Synchronous and asynchronous counters, decade counter; Registers: Shift registers, universal shift register, Ring counters and Johnson counters.

TEXTBOOKS:

1. D. Roy Chowdhury, “Linear Integrated Circuits”, New age international (p) Ltd, 2nd Edition, 2003.

2. Ramakanth A. Gayakwad, “Op-amps and linear ICs”, PHI, 3rd Edition, 2003.

3. John F. Wakerly, “Digital Design Principles and Practices”, Prentice Hall, 3rd Edition, 2005.

4. M. Morris Mano, Michael D. Ciletti, “Digital Design, Pearson Education/PHI, 3rd Edition, 2008.

REFERENCE BOOKS:

1. Salivahanan, "Linear Integrated Circuits and Applications", TMH, 1st Edition, 2008.
2. S P Bali — Linear Integrated Circuits, TMH, 1st Edition, 2008.

WEB REFERENCES:

1. https://nptel.ac.in/courses/108/108/108108111/

COURSE WEB PAGE:

https://lms.iare.ac.in/index?route=course/details&course$_id = 493$

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	https://lms.iare.ac.in/index?route=course/details&course$_id = 493$
CONTENT DELIVERY (THEORY)			
2	Introduction to Integrated Circuits (ICs)	CO1	T1:2.2 T2:1.2-1.7
3	Basics of operational amplifier	CO1	T1:2.5 R1:3.4
4	Differential amplifier	CO1	T1:2.4
5	DC analysis of differential amplifier	CO1	T2:1.12- 1.13
6	AC analysis of differential amplifier	CO1	T1:3.2
7	Characteristics of Op-amps	CO1	T1:3.3-3.4
8	Level shifter circuit	CO1	T1:2.3 R2:12.7
9	Linear applications of op-amps	CO2	T1:11.1-11.5
10	Non-linear applications of op-Amps:1	CO2	T1:4.8
11	Non-linear applications of op-Amps:2	CO2	T1:7.2
12	Active filters-1	CO3	T2:10.4 R2:7.2
13	Active filters-2	CO3	T1:8.2-8.5
14	Timers	CO4	T1:9.2-9.7
15	555 Timer	CO4	T1:10.1
16	Phase Locked Loop (565 PLL)	CO4	T1:10.2
17	Data converters	CO5	T1:10.3 R2:5.4
18	DAC techniques	CO5	T3:3.12 R2:12.7
19	ADC techniques	CO5	T3:7.2
20	Data converter characteristics.	CO5	T3:8.4
21	Logic families	CO6	T1:2.2 T2:1.2-1.7
22	Logic families characteristics-1	CO6	T1:2.5 R1:3.4
23	Logic families characteristics-2	CO6	T1:2.4
24	Resistor Transistor Logic (RTL)	CO6	T2:1.12-1.13
25	Diode Transistor Logic (DTL)	CO6	T1:3.2
26	High Threshold Logic (HTL) Family	CO6	T1:3.3-3.4

27	Transistor -Transistor Logic (TTL) tristate logic	CO6	T1:2.3 R2:12.7
28	Emitter Coupled Logic (ECL) family	CO6	T1:11.1- 11.5
29	CMOS logic family	CO6	T1:4.8
30	CMOS NAND and NOR Gates	CO6	T1:7.2
31	CMOS combinational circuits	CO6	T1:7.2
32	CMOS sequential circuits	CO6	T2:10.4 R2:7.2
33	CMOS sequential circuits	CO6	T1:8.2-8.5
34	CMOS 40XX series ICs	CO6	T1:9.2-9.7
35	IC 7473, IC 7474.	CO6	T1:10.1
36	IC 74194.	CO6	T1:10.2
37	IC 74LS93, IC 74HC163.	CO6	T1:10.3 R2:5.4
38	IC 74HC190	CO6	T3:3.12 R2:12.7
39	Asynchronous up/down counter	CO6	T3:7.2
40	3 Bit UP/DOWN ripple counter	CO6	T3:8.4
41	4 Bit UP/DOWN ripple counter	CO6	T3:8.4
PROBLEM SOLVING/ CASE STUDIES			
42	Problems on Differential amplifier	CO1	T1:2.2 T2:1.2-1.7
43	Problems on AC analysis of differential amplifier	CO1	T1:2.5 R1:3.4
44	Problems on DC analysis of differential amplifier	CO1	T1:2.4
45	Problems on Operational amplifier	CO1	T2:1.12- 1.13
46	Problems on Characteristics of op-amps	CO1	T1:3.2
47	Problems on Linear applications of op-amps	CO2	T1:3.3-3.4
48	Problems on Non-linear applications of op-Amps	CO2	T1:2.3 R2:12.7
49	Problems on Active filters-1	CO3	T1:11.1-11.5
50	Problems on Active filters-2	CO3	T1:4.8
51	Problems on Timers	CO4	T1:7.2
52	Problems on 555 Timer	CO4	T1:7.2
53	Problems on Data converters	CO5	T2:10.4 R2:7.2
54	Problems on CMOS circuit for a Boolean function.	CO6	T1:9.2-9.7
55	Problems on Sequential circuits using IC 7474	CO6	T1:10.1
DISCUSSION ON DEFINITION AND TERMINOLOGY			
56	Amplifier characteristics: input offset voltage. input offset current, CMRR and slew rate of an op-amp.	CO1	T1:2.2 T2:1.2-1.7
57	Voltage Controlled Oscillator (VCO).	CO4	T1:2.5 R1:3.4
58	Define power supply rejection ratio	CO1	T1:2.4
59	Define frequency response.	CO3	T2:1.12-1.13
60	Define threshold voltage and hysteresis.	CO4	T1:3.2
DISCUSSION ON QUESTION BANK			
61	Derive the output voltage of an op-amp based differential amplifier.	CO1	T1:2.2 T2:1.2-1.7
62	Derive the gain expression for inverting operational amplifier and non-inverting operational amplifier.	CO2	T1:2.5 R1:3.4

63	Explain the operation of astable multivibrator using op amp and derive the expression for frequency of oscillations.	CO4	T1:2.4
64	Explain in brief the principle of operation of successive approximation ADC.	CO5	T2:1.12-1.13
65	Implement BCD to 7 segment display decoder using common cathode using 4:16 decoder.	CO6	T1:3.2

Signature of Course Coordinator **HOD,ECE**
M Sreevani, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**

PO 4.	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions **(Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice **(The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**

PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**

PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions **(Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments **(Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**
PO12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change **(Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Power Electronics**				
Course Code	AEE010				
Program	B.Tech				
Semester	V				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	3	2
Course Coordinator	Dr. Ranjith kumar Gatla, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE005	III	Network Analysis
B.Tech	AEC001	III	Electronic Devices and Circuits

II COURSE OVERVIEW:

The course focuses on presenting concepts for conversion, control and monitoring of electrical energy using power semiconductor devices. Methods for analyzing power electronic converters suitable for DC/AC, DC/DC, AC/AC and AC/DC electrical energy conversions including regulators are presented. Additionally, principles for designing power electronic converters, including their power semiconductors and passive elements are established. The applications of power electronics in the fields of sustainable energy technologies, switched mode power supplies and uninterruptible power supplies as well as application of power electronic converters for transmission, distribution and control in the power systems is described.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Power Electronics	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into five units and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
50%	Understand
30%	Apply
10%	Analyze
0%	Evaluate
0%	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz / Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz / AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc.

VI COURSE OBJECTIVES:

The students will try to learn:

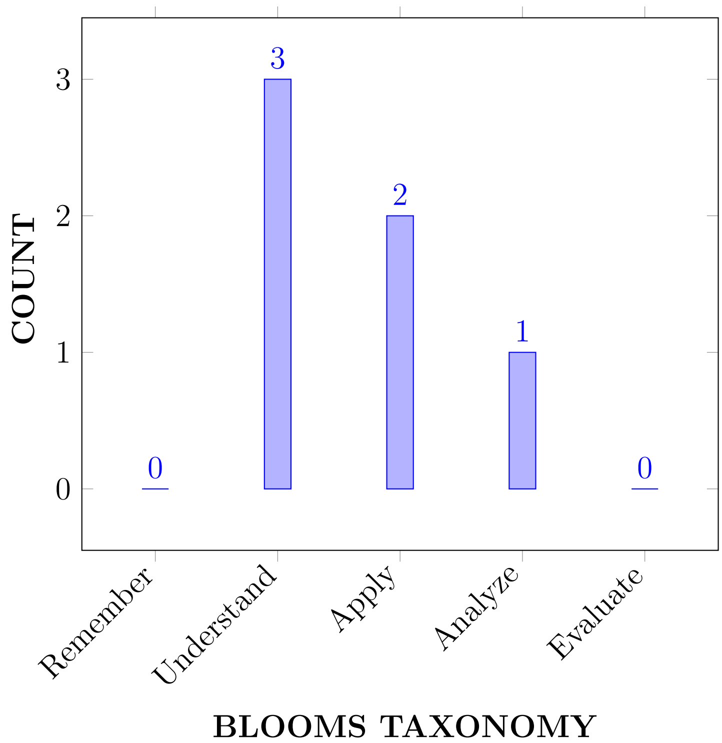
I	The concepts on power semiconductor devices related to its characteristics, ratings, and protection to select these devices for various applications.
II	The fundamental principles and control techniques of power electronic converters for analyzing AC/DC, DC/DC, AC/AC and DC/AC power conversion circuits.
III	The application of power electronic converters in the fields of battery management system, industrial drive applications and enhancement of power quality.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the static and dynamic characteristics of power semiconductor devices used for power conversion in converter circuits.	Understand
CO 2	**Summarize** the various firing circuits and commutation techniques useful for accurate switching function of the SCR.	Understand
CO 3	**Analyze** the performance parameters of ac-dc converters under various loading conditions.	Analyze
CO 4	**Identify** the switching techniques and control strategies in switched mode regulators and perform steady state analysis in the chopper circuit.	Apply
CO 5	**Demonstrate** single phase ac voltage controllers and cyclo converter used for converting fixed ac supply into variable ac output	Understand
CO 6	**Apply** modulation and switching topologies in inverters for output voltage control.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Program Outcomes	
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	2	Seminars
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	1	Seminars

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO(s)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	✓	-	-	✓	✓	-	✓	✓	-	-
CO 2	✓	✓	-	-	-	-	-	-	✓	✓	-	✓	✓	-	-
CO 3	✓	✓	-	-	-	-	-	-	✓	✓	-	✓	✓	✓	-
CO 4	✓	✓	-	✓	-	-	-	-	✓	✓	-	✓	✓	✓	-
CO 5	✓	✓	-	-	-	-	-	-	✓	✓	-	✓	✓	✓	-
CO 6	✓	✓	✓	-	-	-	-	-	✓	✓	-	✓	✓	✓	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO(s) PSO(s)	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Power semi conductor devices are described (Knowledge) through **mathematically** sound and **physics-based models** and circuits made with these devices, capacitor and inductor are analyzed by the **application of first order differential equations**.	3
	PO 2	Understand the given **problem** and **choose** appropriate devices to achieve **desired output** based on performance characteristics of devices.	3
	PO 6	**Understand** the characterstics of power semiconductor devices used in converters for assessment of societial and safety issues **with responsibilities relevant to the professional engineering practice**	1
	PO 9	Focus on working as a member or leader in understanding the characteristics of power devices **individual and team work**.	3
	PO 10	Recognize the role of power semiconductor switches in converter design by **communicating effectively with engineering community.**	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of optimal selection of power devices.	2
	PSO 1	Make use of semiconductor devices for **fabricating** the power electronic systems used in various stages of utilization of electrical energy.	1
CO 2	PO 1	**Identify** the suitable commutation technique, protection and the isolation techniques of thyristors and understand their operation by applying the **principles of mathematics science and engineering fundamentals**. Principles of **energy efficiency** and **heat transfer** are also addressed.	3
	PO 2	Understand problems associated with SCRs during turn on/off and apply this knowledge in design and analysis of protection circuits and commutation circuits by using **first principles of mathematics and engineering sciences**.	3
	PO 9	Focus on working as a member or leader in designing the cummutation circuit to turn off SCR by **individual and team work**.	3
	PO 10	Recognize the role of commutation circuit by **communicating effectively with engineering community.**	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of energy conversion systems.	2

	PSO 1	Make use of the protection and commutation techniques for the circuits associated with power electronic devices for smooth operation while **energy conversion**.	1
CO 3	PO 1	AC-DC converters comprises of semiconductor devices, resistors, capacitors and inductors. The principle of operation and characteristics of such devices are explained by **applying engineering fundamentals including device physics** and deduce the expressions using **mathematical principles**.	3
	PO 2	Design (formulate) ac-dc converter for power electronics systems to meet given objectives (problem statement & formulation) under realistic constraints. Designs are tested (validation) through numerical simulation or hardware implementation (experimental design), and modifications are implemented as needed (interpretation of results) using **first principles of mathematics and engineering sciences**.	5
	PO 9	Focus on working as a member or leader in designing the rectifier circuits by **individual and team wor**k.	3
	PO 10	Recognize the role of pulse width modulation technique in three phase controlled rectifiers by **communicating effectively with engineering community**.	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of optimal selection of power devices to design rectifier.	4
	PSO 1	**Design and simulate** converter circuits to rectify electrical energy in various applications. .	1
	PSO 2	Utilize DC-DC converters to constant and reliable energy for **applications** includes mobile chargers, electric vehicles and **industrial drives**.	1
CO 4	PO 1	Identify (Knowledge) suitable switching techniques and control strategies to operate DC-DC converters with the **Knowledge of mathematics, science and engineering fundamentals related to electrical engineering**.	3
	PO 2	Design (formulate) dc-dc converter for power electronics systems to meet given objectives (problem statement & formulation). Designs are tested (validation) through numerical simulation or hardware implementation (experimental design), and modifications are implemented as needed (interpretation of results) **using first principles of science and mathematics**	6
	PO 4	**Identify the Various switching techniques** to apply the different control stratagies and understand the corresponding **context of engineering knowledge related** to the performance indicators and measures in the swtched mode regulators	6

	PO 9	Focus on working as a member or leader in designing the regulated power supplies using chopper circuits by **individual and team work**.	3
	PO 10	Recognize the role of passive components and switches in choppers by **communicating effectively with engineering community.**	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of designing the regulated power supplies using chopper circuits.	4
	PSO 1	**Design** the converter circuits to perform DC-DC conversion and interpret the results through **simulation** and hardware implementation.	1
	PSO 2	Make use of ac-dc converters for **energy conversion** to operate electrical drives in various **applications**.	1
CO 5	PO 1	Analyze AC voltage controller circuits using **fundamentals of engineering and science** including the application of **first order differential equations** in the roles of capacitance and inductance in power electronics circuits.	3
	PO 2	Identify the problems associated with conversion of fixed AC supply into variable output and apply suitable control to achieve desired output. The developed models and control strategies are validated through numerical simulation or hardware implementation and modifications are implemented as needed (interpretation of results) **using first principles of science and mathematics**	5
	PO 9	Focus on working as a member or leader in designing the AC voltage controllers by **individual and team work**.	3
	PO 10	Recognize the role of semiconductro devices in ac voltage controllers by **communicating effectively with engineering community**.	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of designing the AC voltage cotroller.	4
	PSO 1	**Design** the converter circuits to perform AC-AC conversion to achieve desired voltage output and interpret the results through **simulation** and hardware implementation.	1
	PSO 2	Make use of ac-ac converters for **energy conversion** to control the speed of electrical drives used in **industrial applications**.	1
CO 6	PO 1	Explain the concepts and working principle involved in inverter circuits with **the knowledge of mathematics, science and engineering fundamentals related basic electrical and electronics**.	3

	PO 2	Select a suitable switching technique for inverter to obtain **desired** output voltage. The techniques and corresponding models are **validated** through numerical simulation or hardware implementation and results are **interpreted using first principles of mathematics and engineering fundamentals**.	5
	PO 3	The **design** of inverter systems includes interfacing with alternate energy sources and improvement of **energy efficiency**, both of which are tied into the **global, economic, environmental and societal context**.	4
	PO 9	Focus on working as a member or leader in designing the inverter circuits by **individual and team work**.	3
	PO 10	Recognize the role of modulation techniques in output voltage control of inverters by **communicating effectively with engineering community**.	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of designing the Inverter circuit.	4
	PSO 1	**Design** the inverter circuit to perform DC-AC conversion and interpret the results through **simulation** and hardware implementation.	1
	PSO 2	Make use of inverters to drive the **appliances** and other **devices** connected to it by energy conversion.	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO(s)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	-	-	-	1	-	-	3	1	-	2	1	-	-
CO 2	3	3	-	-	-	-	-	-	3	1	-	4	1	-	-
CO 3	3	5	-	-	-	-	-	-	3	1	-	4	1	1	-
CO 4	3	6	-	6	-	-	-	-	3	1	-	4	1	1	-
CO 5	3	5	-	-	-	-	-	-	3	1	-	4	1	1	-
CO 6	3	5	4	-	-	-	-	-	3	1	-	4	1	1	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO(s)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	30	-	-	-	20	-	-	25	25	-	25	50	-	-
CO 2	100	30	-	-	-	-	-	-	25	25	-	50	50	-	-
CO 3	100	50	-	-	-	-	-	-	25	25	-	50	50	33.3	-
CO 4	100	60	-	54.5	-	-	-	-	25	25	-	50	50	33.3	-
CO 5	100	50	-	-	-	-	-	-	25	25	-	50	50	33.3	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO(s)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 6	100	50	40	-	-	-	-	-	25	25	-	50	50	33.3	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 - $5 < C \leq 40\%$ – Low/ Slight
2 - $40\ \% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO(s)		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	1	-	-	-	1	-	-	1	1	-	1	2	-	-
CO 2	3	1	-	-	-	-	-	-	1	1	-	2	2	-	-
CO 3	3	2	-	-	-	-	-	-	1	1	-	2	2	1	-
CO 4	3	3	-	2	-	-	-	-	1	1	-	2	2	1	-
CO 5	3	2	-	-	-	-	-	-	1	1	-	2	2	1	-
CO 6	3	2	1	-	-	-	-	-	1	1	-	2	2	1	-
TOTAL	18	11	1	2	-	1	-	-	6	6	-	11	12	4	-
AVERAGE	3	2	1	1	-	1	-	-	1	1	-	2	2	1	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	-
Quiz	-	Tech-Talk	✓	Certification	-
Term Paper	-	Seminars	-	Student Viva	-
Laboratory Practice	-	5 Minutes Video / Concept Video	✓	Open Ended Experiments	-
Micro Projects	-	-	-	-	

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**POWER SWITCHING DEVICES AND COMMUTATION CIRCUITS**
	Power semiconductor devices and commutation circuits: Thyristors, principle of operation of silicon controlled rectifiers (SCR), bipolar junction transistor (BJT), power metal oxide semiconductor field effect transistor (MOSFET), power insulated gate bipolar transistor (IGBT), gate turn off thyristor (GTO) and characteristics, turn on and turnoff methods, dynamic characteristics of SCR, two transistor analogy, unijunction transistor firing circuit, series and parallel operation of SCRs, design of snubber circuit; Specifications and ratings: Ratings of SCR, BJT and IGBT, line commutation and forced commutation circuits, numerical problems.
MODULE II	**SINGLE PHASE AND THREE PHASE CONTROLLED RECTIFIERS**
	AC - DC converters: Phase control technique, single phase line commutated converters, midpoint and bridge connections, half controlled converters and semi converters with R, RL and RLE loads, derivation of average load voltage and current, active and reactive power inputs to the converters without and with freewheeling diode, numerical problems; Fully controlled converters: Midpoint and bridge connections with R, RL loads and RLE load, derivation of average load voltage and current, line commutated inverters, active and reactive power inputs to the converters without and with freewheeling diode, derivation of load voltage and current, numerical problems; Three phase converters: Three pulse and six pulse converters, midpoint and bridge connections, average load voltage with R and RL loads, effect of source inductance, operation of single phase and three phase dual converters, numerical problems.
MODULE III	**AC VOLTAGE CONTROLLERS AND CYCLOCONVERTERS**
	AC - AC controllers: Introduction, single phase two SCRs in anti – parallel with R and RL loads, modes of operation of triac, triac with R and RL loads, derivation of RMS load voltage, current and power factor, wave forms, numerical problems. Cycloconverters: Principle of operation of single phase midpoint and bridge type cycloconverters with resistive and inductive loads, continuous and discontinuous mode of operation.
MODULE IV	**DC – DC CONVERTERS**
	DC - DC converters: Principle of operation of choppers, time ratio control and current limit control strategies, types of choppers, derivation of load voltage and currents with R, RL and RLE loads, AC chopper, problems; Switched mode regulators: Study of buck, boost and buck - boost regulators, Cuk regulators.
MODULE V	**INVERTERS**
	DC - AC converters: Single phase inverter, basic series inverter, parallel inverter, operation and waveforms, voltage source inverter (VSI), three phase inverters 180^0 , 120^0 conduction modes of operation, voltage control techniques for inverters, pulse width modulation techniques, reduction of harmonics, current source inverter (CSI) with ideal switches, capacitor commutated type CSI, numerical problems.

TEXTBOOKS

1. M D Singh, K B Kanchandhani, “Power Electronics”, Tata McGraw-Hill Publishing Company, 2 nd Edition, 1998.
2. Dr. P S Bimbhra, “Power Electronics”, Khanna Publishers, 5th Edition, 2012.
3. Ned Mohan, Tore M Undeland, William P Robbins, “Power Electronics: Converters, Applications, and Design”, 3 rd Edition, John Wiley and sons, 2002.
4. M H Rashid, “Power Electronics, Circuits, Devices and Applications”, Pearson, 3rd Edition, 2001.

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1. Vedam Subramanyam, “Power Electronics”, New Age International Limited, 2nd Edition, 2006.
2. P C Sen, “Power Electronics”, Tata McGraw-Hill Publishing, 1st Edition, 1987.
3. G K Dubey, S R Doradra, A Joshi, R M K Sinha, “Thyristorised Power Controllers”, New Age International Limited, 2nd Edition, 2008.

WEB REFERENCES:

1. https://www.coursera.org/learn/power-electronics
2. https://nptel.ac.in/courses/108/102/108102145/
3. https://www.electronicsforu.com/videos-slideshows/power-electronic-devices
4. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-334-power-electronics- spring-2007/lecture-notes/

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO’s	Reference T1: 4.1
	OBE DISCUSSION		
1	Course Description on Outcome Based Education (OBE)		
	CONTENT DELIVERY (THEORY)		
2	Basic elements of power electronics and devices	CO1	T2: 1.1 R2: 1.1
3	Thyristors (SCR’s) characteristics	CO1	T2: 1.1 R2: 1.1
4	Two transistor analogy of SCR	CO1	T2: 1.1 R2: 1.1
5	Operation of SCR and Turn on methods	CO2	T2: 1.1 R2: 1.1
6	Turn off method of SCR class A and Class B commutation	CO2	T2: 1.1 R2: 1.1

7	Turn off method of SCR class C, Class D, class E commutation and natural commutation	CO2	T2: 5.5 R2: 1.7
8	Dynamic characteristics of SCR and Operation of UJT firing circuit	CO1	T2: 5.5 R2: 1.7 T2: 5.5 R2: 1.7
9	Series and parallel connections of SCR's	CO2	T2: 5.5 R2: 1.7
10	Snubber circuit for SCR	CO2	T2: 5.5 R2: 1.7
11	Characteristics of BJT and Power MOSFET	CO1	T2: 5.5 R2: 1.7
12	Characteristics of Power IGBT and GTO	CO1	T2: 5.5 R2: 1.7
13	Specifications and ratings: Ratings of SCR, BJT and IGBT	CO1	T2: 5.5 R2: 1.7
14	Phase controlled rectifiers (1ph) and Operation of half converter with R, RL and RLE loads	CO3	T2: 5.5 T2:6.1.1 R2: 1.7
15	Fully controlled converter with R, RL and RLE loads	CO3	T2: 6.3.1 T2: 6.3.2 R2: 5.2 R2: 5.4
16	Effect of source inductance on converter	CO3	T2: 6.3.2 R2:5.5
17	3-ph Half controlled converters with Resistive load and necessary derivations for analysis	CO3	T2: 6.6.2 R2: 6.1
18	3-ph fully controlled converters with R & RL load and necessary derivations	CO3	T2: 6.6.3 R2: 6.4
19	3-ph full controlled converters with RLE load and necessary derivations	CO3	T2: 6.6.3 R2: 6.4
20	Effect of source inductance in three phase rectifiers	CO3	T2: 6.7.2 R2: 4.11
21	Introduction to Dual Converters and operation of Single phase, three phase dual converter operation	CO3	T2: 6.8 T2: 6.9 R2: 6.11 R2: 6.11
22	Principle of operation of single phase AC voltage controller	CO5	T2: 9.1 T2: 9.2 R2: 8.5 R2: 8.1
23	Modes of operation of Triac	CO1	T2: 9.3.2 R2: 8.12
24	Principle of operation and control strategies of Cyclo converters	CO5	T2: 10.1 R2: 9.41
25	Single phase midpoint Cyclo converters with resistive load	CO5	T2: 10.1.1 R2: 9.42

26	Single phase Cyclo converter Bridge configuration Waveforms	CO5	T2: 10.1.2 R2: 9.42.1
27	Principle and control strategies of choppers	CO4	T2: 7.1 R2: 9.40
28	Operation of Step up and step down choppers	CO4	T2: 7. R2: 9.40.1
29	Operation of class A chopper	CO4	T2: 7.4.1, R2: 9.40.3
30	Operation of class B and class C chopper	CO4	T2: 7.4.2 R2: 9.40.4
31	Operation of Class D and class E chopper	CO4	T2: 7.4.4 R2: 9.40.5
32	Operation of Switched mode regulators	CO4	T2: 7. R2: 10.3
33	Single Phase inverter and operation of Single phase half bridge inverter	CO6	T2: 8.1.1, R2: 9.1
34	Single phase full bridge inverter and series inverter	CO6	T2: 8.9 R2: 9.2
35	Parallel Capacitor inverter	CO6	T2: 8.10 R2: 9.6
36	Three phase Voltage source inverter 180 dergee conduction mode	CO6	T2: 8.4.1 R2: 9.32
37	Three phase Voltage source inverter 120 dergee conduction mode	CO6	T2: 8.4.2 R2: 9.33
38	Voltage control and PWM techniques for inverters	CO6	T2: 8.5 R2: 9.36
39	Sinusoidal pulse width modulation	CO6	T2: 8.6.3 R2: 9.37
40	Current source inverter with ideal switches	CO6	T2: 8.8.1 R2: 9.38
41	Operation of commutated type CSI	CO6	T2: 8.8.2 R2: 9.17
PROBLEM SOLVING/ CASE STUDIES			
42	Numerical problems on Series and parallel connections of SCR's	CO2	T2: 4.9 R2: 1.10
43	Numerical problems on half controlled converters	CO3	T2: 6.1.2 R2: 5.1.2
44	Numerical problems on fully controlled converters	CO3	T2: 6.9 R2:5.4
45	Numerical problems on fully controlled converters with RL load	CO3	T2: 6.9 R2:5.4

46	Numerical problems on dual converters	CO3	T2: 6.8 T2: 6.9
47	Problems on three phase half controlled converters	CO3	T2: 6.6.2 R2:6.1
48	Problems on three phase full controlled converters	CO3	T2: 6.6.2 R2:6.1
49	Problems on three phase full controlled converters with RL loads	CO3	T2: 6.6.3 R2:6.2
50	Problems on three phase full controlled converters with RL loads	CO3	T2: 6.6.3 R2:6.2
51	Numerical problems on AC voltage controller	CO5	T2: 9.3.2 R2: 8.4
52	Numerical problems on AC voltage controller with RL loads	CO5	T2: 9.3.2 R2: 8.4
53	Numerical problems on cycloconverters	CO5	T2: 10.1.2 R2: 9.42.2
54	Numerical problems on choppers	CO4	T2: 7.7 R2: 9.40.1
55	Numerical problems on step down and step up choppers	CO4	T2: 7.7 R2: 9.40.1
56	Numerical problems on switched mode regulators	CO4	T2: 7.5 R2: 10.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Power electronic devices, SCR characteristics, turn on and turn off methods for SCRs	CO1, CO2	T2: 1.1 T2: 5.1 R2: 1.7 R2: 1.1
58	Phase controlled rectifiers with different loads and dual converters	CO3	T2: 6.1 R2: 5.1
59	AC voltage regulators and cycloconverters	CO5	T2: 9.1 T2: 10.1 R2: 9.41 R2: 8.1
60	Choppers and switched mode regulators	CO4	T2: 7.1 T2: 7.6 R2: 10.3 R2: 9.40
61	Voltage source inverters and current source inverters	CO6	T2: 8.8.1 T2: 8.1.1 R2: 9.1 R2: 9.38
DISCUSSION OF QUESTION BANK			
1	Power Switching Devices	CO1,CO2	-
2	Phase Controlled Rectifiers	CO3	-
3	Choppers	CO5	-

4	AC Voltage Controller and Cyclo Converters	CO4	-
5	Inverters	CO6	-

Signature of Course Coordinator **HOD,EEE**

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF(s)
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences **(Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations **(Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions	**10**

	5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**

PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project.	**12**

	6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	
PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**
PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer. 1. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**COMPUTER SCIENCE AND ENGINEERING**				
Course Title	**OPTIMIZATION TECHNIQUES**				
Course Code	AHS012				
Program	B.Tech				
Semester	V				
Course Type	Core				
Regulation	R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	1	3	-	-
Course Coordinator	Dr K Suvarchala, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS003	I	Computational Mathematics and Integral Calculus

II COURSE OVERVIEW:

The primary objective of this course is to introduce the methods of optimization techniques, precise mathematical concept, study how to design algorithms, establish their correctness, study their efficiency and memory needs. The goal is to maintain a balance between theory, numerical computation, and problem setup for solution by optimization software and applications to engineering systems.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Discrete Mathematical Structures	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could

be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
40 %	Understand
50 %	Apply
0 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

I	Learn fundamentals of linear programming through optimization
II	Apply the mathematical results and numerical techniques of optimization theory to concrete Engineering Problems

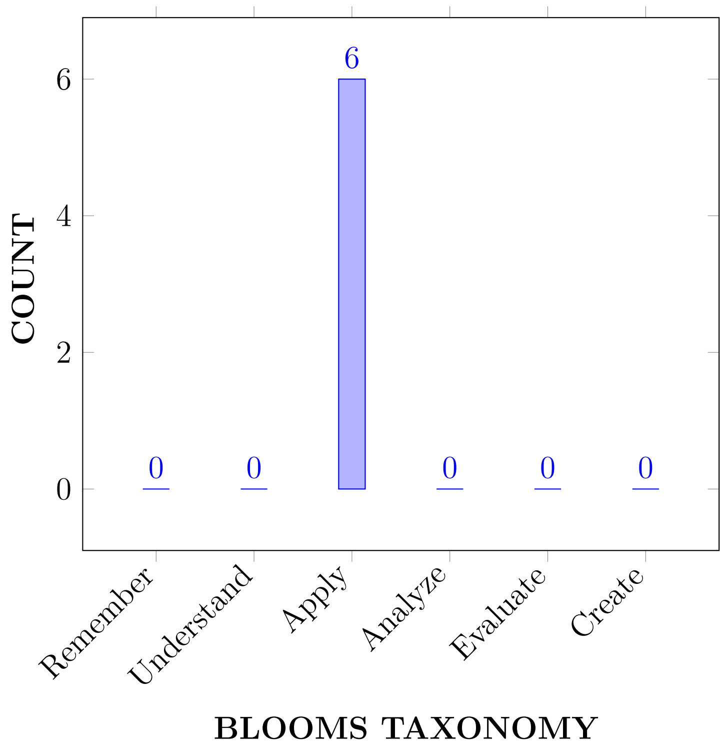
III	Understand and apply optimization techniques to industrial applications.
IV	Apply the dynamic programming and quadratic approximation to electrical and electronic problems and applications

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Solve** Linear Programming Problems of different applications in engineering by formulating LP model with optimization principles.	Apply
CO 2	**Make use of** transportation and assignment problems to obtain feasible and optimal values in allocating and assigning resources for real-time applications.	Apply
CO 3	**Select** appropriate game theory and sequencing technique to reduce conflicting solutions and in completion of jobs with minimum possible time.	Apply
CO 4	**Choose** appropriate dynamic programming methods to transform complex optimization problem into sequence of simpler in solving various types of problems.	Apply
CO 5	**Identify** dappropriate quadratic approximation techniques to solve constrained optimization problems.	Apply
CO 6	**Develop** an ability to identify, formulate and solve simple and complex engineering problems Iby using appropriate optimization technique.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE / CIE / AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	SEE / CIE / AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3	SEE / CIE / AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	SEE / CIE / AAT
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	SEE / CIE / AAT
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	1	SEE / CIE / AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	**Understand, design and analyze** computer programs in the areas related to Algorithms, System Software, Web design, Big data, Artificial Intelligence, Machine Learning and Networking.	3	SEE/AAT

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 3	**Make use of** modern computer tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2	SEE/AAT

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	✓	-	-	-	-	-	-	✓	-	✓	✓	-	✓
CO 2	✓	✓	✓	✓	-	-	-	-	-	✓	-	✓	✓	-	✓
CO 3	✓	✓	✓	-	-	-	-	-	-	✓	-	✓	✓	-	✓
CO 4	✓	✓	✓	-	-	-	-	-	-	✓	-	✓	✓	-	✓
CO 5	✓	✓	✓	✓	-	-	-	-	-	✓	-	✓	✓	-	✓
CO 6	✓	✓	✓	✓	-	-	-	-	-	✓	-	✓	✓	-	✓

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Linear Programming Problems of different applications in engineering are solved by using scientific, mathematical and own engineering discipline principles.	3
	PO 2	Linear Programming Problems of different applications in engineering are solved by identifying, defining and formulating the problem with data collection, solution development and interpretation of results.	6
	PO 3	Design/Development of solution for LP models of different engineering applications to meet the specified needs with appropriate Consideration of various constraints.	6
	PO 10	Linear programming problems will be solved with clear applications of engineering and optimization principals.	2
	PO 12	Applying LP problems in computer science related, industry oriented applications for continous development.	3
	PSO 1	Formulate LP problems for given statement with constraints, design and develop an algorithm to solve the same for voluminous data processing .	4
	PSO 3	Apply knowledge on frameworks associated with optimization techniques for solving LP problems	1

CO 2	PO 1	Transportation and Assignment Problems of different applications in engineering are solved by using scientific, mathematical and own engineering discipline principles	3
	PO 2	Transportation and Assignment problems of different real time applications in engineering are solved by identifying, defining and formulating the problem with data collection, solution development and interpretation of results.	7
	PO 3	Design/Development of solution for Transportation and Assignment models of different engineering applications to meet the specified needs with appropriate Consideration of allocating and assigning resources for real-time applications.	6
	PO 4	Use the knowledge of characteristics of transportation and Assignment methods to design , analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	8
	PO 10	Transportation and Assignment problems will be solved with clear applications of engineering and optimization principals.	2
	PO 12	Applying Transportation and Assignment problems in computer science related, industry oriented applications for continous development.	3
	PSO 1	Formulate Transportation and Assignment problems for given statement with constraints, design and develop an algorithm to solve the same for voluminous data processing .	4
	PSO 3	Apply knowledge on frameworks associated with optimization techniques for solving Transportation and Assignment problems	1
CO 3	PO 1	Selection of algorithm for assigning a suitable person to existing vacancy of jobs positions, need the knowledge of science and engineering fundamentals	3
	PO 2	Problem analysis based on principles of mathematics, Manufacturing engineering fundamentals and sciences is essential to identify and analyze the material distribution schedule to minimize total distribution cost	8
	PO 3	Design/Development of solution for Sequencing and Game Theory to reduce conflicting solutions and in completion of jobs with minimum possible time of different engineering applications to meet the specified needs with appropriate Consideration.	8
	PO 10	Sequencing and Game Theory problems will be solved with clear applications of engineering and optimization principals.	2
	PO 12	Applying Sequencing and Game Theory problems in computer science related, industry oriented applications for continuous development.	3

	PSO 1	Formulate Sequencing and Game Theory problems for given statement with constraints, design and develop an algorithm to solve the same for voluminous data processing.	4
	PSO 3	Develop practical experience for solving the real time problem using computational and experimental tools in the field of Manufacturing process	1
CO 4	PO 1	Analyze the dynamic programming concepts to solve shortest path and queuing models by applying the knowledge of mathematics, science and metrology engineering fundamentals.	3
	PO 2	Choose appropriate dynamic programming methods to transform complex optimization problem into sequence of simpler in solving various types of real time applications in engineering are solved by identifying, defining and formulating the problem with data collection, solution development and interpretation of results.	6
	PO 3	Design/Development of solution for dynamic programming problems of different engineering applications to meet the specified needs with appropriate Consideration.	6
	PO 10	Dynamic Programming problems will be solved with clear applications of engineering and optimization principals.	2
	PO 12	Applying Dynamic Programming problems problems in computer science related, industry oriented applications for continous development.	3
	PSO 1	Formulate for the given statement with constraints, design and develop an algorithm to solve the same for voluminous data processing.	4
	PSO 3	Apply knowledge on frameworks associated with optimization techniques for solving Dynamic Programming problems problems	1
CO 5	PO 1	Quadratic approximation techniques to solve constrained optimization problems by using scientific, mathematical and own engineering discipline principles	3
	PO 2	Direct Quadratic Approximation of different real time applications in engineering are solved by identifying, defining and formulating the problem with data collection, solution development and interpretation of results.	8
	PO 3	Design/Development of solution for Direct Quadratic Approximation problems to solve constrained optimization problems of different engineering applications to meet the specified needs with appropriate Consideration.	8
	PO 4	Use the knowledge of characteristics of Quadrartric Approximation to design , analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	8

	PO 10	Direct Quadratic Approximation problems will be solved with clear applications of engineering and optimization principals.	2
	PO 12	Applying Direct Quadratic Approximation problems in computer science related, industry oriented applications for continous development.	3
	PSO 1	Formulate Direct Quadratic Approximation problems for given statement with constraints, design and develop an algorithm to solve the same for voluminous data processing .	4
	PSO 3	Apply knowledge on frameworks associated with optimization techniques for solving Direct Quadratic Approximation problems	1
CO 6	PO 1	Complex engineering problems are solved by using scientific, mathematical and own engineering discipline principles	3
	PO 2	Complex engineering problems of different real time applications in engineering are solved by identifying, defining and formulating the problem with data collection, solution development and interpretation of results.	8
	PO 3	Design/Development of solution for Complex engineering problems of different engineering applications to meet the specified needs with appropriate Consideration.	8
	PO 4	Use the knowledge of characteristics of optimization techniques to design , analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	8
	PO 10	Complex engineering problems will be solved with clear applications of engineering and optimization principals.	2
	PO 12	Applying Complex engineering problems in computer science related, industry oriented applications for continous development.	3
	PSO 1	Formulate Complex engineering problems for the given statement with constraints, design and develop an algorithm to solve the same for voluminous data processing .	4
	PSO 3	Apply knowledge on frameworks associated with optimization techniques for solving Complex Engineering problems	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	6	6	-	-	-	-	-	-	2	-	3	4	-	1
CO 2	3	7	6	8	-	-	-	-	-	2	-	3	4	-	1
CO 3	3	8	8	-	-	-	-	-	-	2	-	3	4	-	1
CO 4	3	6	6	-	-	-	-	-	-	2	-	3	4	-	1
CO 5	3	8	8	8	-	-	-	-	-	2	-	3	4	-	1
CO 6	3	8	8	8	-	-	-	-	-	2	-	3	4	-	1

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100.0	60.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	37.5	66.66	0.0	50.0
CO 2	100.0	70.0	60.0	72.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	37.5	66.66	0.0	50.0
CO 3	100.0	80.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	37.5	66.66	0.0	50.0
CO 4	100.0	60.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	37.5	66.66	0.0	50.0
CO 5	100.0	80.0	80.0	72.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	37.5	66.66	0.0	50.0
CO 6	100.0	80.0	80.0	72.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	37.5	66.66	0.0	50.0

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	3	-	-	-	-	-	-	1	-	1	3	-	2
CO 2	3	3	3	3	-	-	-	-	-	1	-	1	3	-	2
CO 3	3	3	3	-	-	-	-	-	-	1	-	1	3	-	2
CO 4	3	3	3	-	-	-	-	-	-	1	-	1	3	-	2
CO 5	3	3	3	3	-	-	-	-	-	1	-	1	3	-	2
CO 6	3	3	3	3	-	-	-	-	-	1	-	1	3	-	2
TOTAL	18	18	18	9	-	-	-	-	-	6	-	6	18	-	12
AVERAGE	3.0	3.0	3.0	3.0	-	-	-	-	-	1	-	1	3.0	-	2

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVIII SYLLABUS:

MODULE I	**LINEAR PROGRAMMING**
	Definition, characteristics and phases, types of models, operations research models, applications, linear programming problem formulation, graphical solution, simplex method; Artificial variables techniques: Two-phase method, Big-M method.
MODULE II	**TRANSPORTATION AND ASSIGNMENT PROBLEMS**
	Transportation problem, formulation, optimal solution, unbalanced transportation problem, degeneracy, assignment problem, formulation, optimal solution, variants of assignment problem, traveling salesman problem
MODULE III	**SEQUENCING AND THEORY OF GAMES**
	Sequencing: Introduction, flow-shop sequencing, n jobs through two machines, n jobs through three machines, job shop sequencing two jobs through m machines. Theory of games: Introduction, terminology, solution of games with saddle points and without saddle points, 2 x 2 games, dominance principle, m x 2 and 2 x n games, graphical method.
MODULE IV	**DYNAMIC PROGRAMMING**
	Introduction: Terminology, Bellman's principle of optimality, applications of dynamic programming shortest path problem, linear programming problem.
MODULE V	**QUADRATIC APPROXIMATION**
	Quadratic approximation methods for constrained problems: Direct quadratic approximation, quadratic approximation of the Lagrangian function, variable metric methods for constrained optimization

TEXTBOOKS

1. A Ravindran, “Engineering Optimization”, JohnWiley&Sons Publications, 4thEdition, 2009.
2. Hillier, Liberman, “Introduction to Operation Research”, Tata McGraw-Hill, 2nd Edition,2000.

REFERENCE BOOKS:

1. Dr. J K Sharma, “Operation Research”, Mac Milan Publications, 5thEdition, 2013.
2. Ronald L. Rardin, “Optimization in Operation Research”, Pearson Education Pvt. Limited, 2005.
3. N V S Raju, “Operation Research”, S M S Education, 3rdRevised Edition.

WEB REFERENCES:

1. http://www.web.stanford.edu/class/cs103x
2. http://www.saylor.org/course/cs202/.
3. http://www.cse.iitd.ernet.in/ bagchi/courses/discrete-book

COURSE WEB PAGE:

1. https://lms.iare.ac.in/index ?route=course/details& course id=84

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO’s	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	https://lms.iare.ac.in/index ?route=course/details& course id=84
CONTENT DELIVERY (THEORY)			
1-3	Definition, characteristics and phases, types of models	CO 1, ,CO 6	T1:1.1,1.2
4-6	operations research models, applications	CO 1,CO 6	T1: 1.2.7, 1.2.8
7	linear programming problem formulation, graphical solution	CO 1	T1:1.2.9, 1.2.11, 1.3
8– 14	simplex method, Artificial variables techniques: Two-phase method, Big-M method	CO 1	T1:1.5, 1.4.2,1.4.3
15-20	Transportation problem, formulation, optimal solution, unbalanced transportation problem	CO 2,CO 6	T1:1.4.3, 1.4.4,2.3.1, 2.3.2,2.3.6,2.3.7,2.3.8
21-25	degeneracy, assignment problem, formulation, optimal solution, variants of assignment problem	CO 2	R2:4.3 T1:2.4.1, 2.4.2,2.4.3, 4.1

26-29	traveling salesman problem, Sequencing: Introduction, flow-shop sequencing	CO 2,CO 3,CO 6	T1:3.1,3.2 R1:6.2-6.8
30-35	n jobs through two machines, n jobs through three machines, job shop sequencing two jobs through m machines.	CO 3 ,CO 6	R1: 7.1-7.6
36-38	Theory of games: Introduction, terminology, solution of games with saddle points and without saddle points	CO 3,CO 6	R2:8.1
39-44	2 x 2 games, dominance principle, m x 2 and 2 x n games, graphical method	CO 3	R2:8.2, 8.3
45-48	Introduction: Terminology, Bellman's principle of optimality	CO 4,CO 6	R2: 9.1-9.3
49-54	Applications of dynamic programming shortest path problem, linear programming problem.	CO 4	R2: 9.8, 9.9, 10.1, 10.2
55-59	Quadratic approximation methods for constrained problems: Direct quadratic approximation, quadratic approximation of the Lagrangian function	CO 5,CO 6	T2:5.5, 5.9, 5.10
60	variable metric methods for constrained optimization	CO 5,CO 6	R2:10.4, 10.6,10.7
PROBLEM SOLVING/ CASE STUDIES			
1	Problems on Linear programming formulation	CO1,CO 6	T2:2.1
2	Problems on Simplex methods	CO1	T2:2.3
3	Problems on graphical method	CO1,CO 6	T2:2.3.1
4	Problems on transportation formulation	CO 2	T2:7.2,7.3
5	Problems on Assignment formulation	CO 2,CO 6	T2:10.3.1
6	Problems on unbalanced transportation problems	CO 2,CO 6	T2:13.3.2, 13.4.1
7	Problems on Degeneracy	CO 2	T2:17.1.1, 17.1.3
8	Problems on n jobs on two/three/n machines	CO 2,CO 6	T2:18.3.4, 18.3.4.1
9	Problems on games with saddle point and without saddle point	CO 3	T2:22.12, 19.1.2
10	Problems on 2X2,mx2,2xn and graphical method.	CO 3,CO 6	T2:18.4, 18.4.3
11	Problems on shortest path algorithm	CO 5,CO 6	T2:19.2, 18.4.4
12	Problems on variable metric methods for constrained optimization	CO 5,CO 6	T2:23.1.1, 23.1.3
DISCUSSION ON DEFINITION AND TERMINOLOGY			
1	Definition on Linear programming	CO 1,CO 6	T2:18.3.4, 18.3.4.1
2	Definition on Transportation and Assignment problems	CO 2,CO 6	T2:22.12, 19.1.2
3	Definition on Sequencing and Game theory	CO 3,CO 6	T2:18.4, 18.4.3
4	Definitions on Quadratic Approximation	CO 4,CO 6	T2:19.2, 18.4.4

5	Definitions on Direct Quadratric Approximation	CO 5, CO6	T2:23.1.1, 23.1.3
DISCUSSION ON QUESTION BANK			
1	Linear Programming	CO 1, CO 6	T2:18.3.4, 18.3.4.1
2	Transporatation and Assignment problems	CO 2, CO 6	T2:22.12, 19.1.2
3	Sequencing and Game TheoryI	CO 3, CO6,	T2:18.4, 18.4.3
4	Quadratric Approximation	CO4, CO 6	T2:19.2, 18.4.4
5	Direct Quadratric Approximation	CO 5, CO 6	T2:23.1.1, 23.1.3

Course Coordinator **HOD,CSE**
Dr K Suvarchala, Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Transmission and Distribution Systems**				
Course Code	AEE011				
Program	B. Tech				
Semester	V				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. P Mabuhussain, Assistant Professor, EEE				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE005	III	Network Analysis
B.Tech	AEE003	IV	Power Generation Systems

II COURSE OVERVIEW:

This course deals with the modeling, analysis and design of electrical power transmission lines. It gives an emphasis on overhead line insulators, underground cables, corona phenomena,sag and tension calculation, AC and DC distribution systems, substation design and equipment, voltage drop calculations in AC and DC distributors fed at one end or both ends. Also a brief overview is presented about Indian grid scenario and the Indian Electricity rules.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Transmission and Distribution Systems	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage

in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
50 %	Understand
40%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
50%	50%	-

VI COURSE OBJECTIVES:

The students will try to learn:

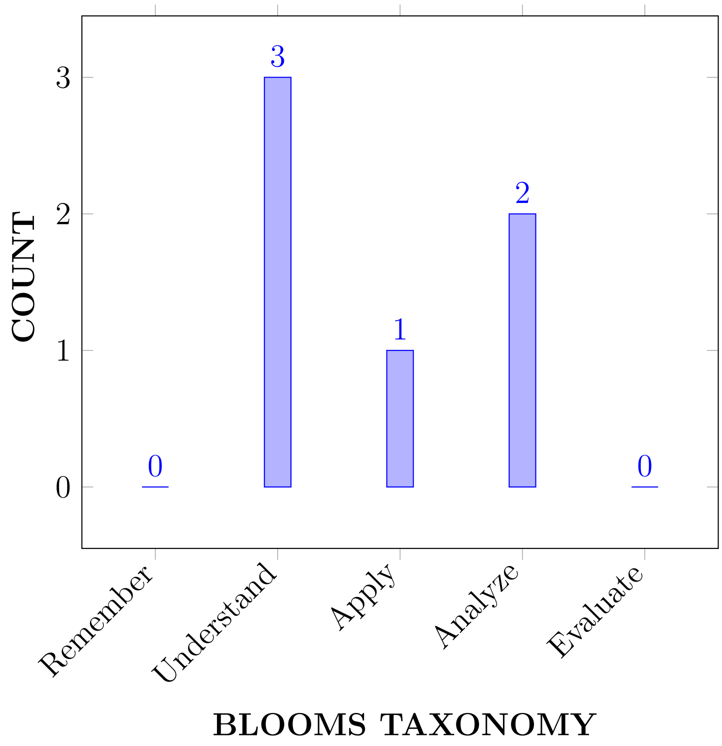
I	The mathematical solutions for transmission line parameters of a single phase and three phase system.
II	The mathematical modeling of short, medium and long transmission linesalong with the transient behavior.
III	The mechanical design of overhead transmission lines, the use of insulators and underground cables in electrical power transmission system.
IV	The requirements of distribution system, substaion equipment and voltage drop caculations in AC and DC distributors.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Compute** the line parameters and corona loss for electrical desing of a tranmission line system.	Analyze
CO 2	**Model** the short, medium and long transmission lines using ABCD constants for evalutating the performance of tranmission system under no load and surge impedance loading conditions.	Apply
CO 3	**Examine** the different types of insulators and the methods for improving string effciciency in the design of ovehead transmission system.	Understand
CO 4	**Calculate** the insulation resistance, capacitance and dielectric stress in underground cable transmission system to increase the efficiency and quality operation of cables.	Understand
CO 5	**Analyze** the sag and tension for designing the overhead tranmsission line under various loading and weather conditions.	Analyze
CO 6	**Determine** the voltage drop in AC and DC distgribution feeders and select the appropriate substation equipment for efficient distribution of electrical power to consumers.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

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IX PROGRAM SPECIFIC OUTCOMES:

Program Specific Outcomes	
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.
PSO 3	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.

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X HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/AAT/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	CIE/AAT/SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/AAT/SEE

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	CIE/AAT/SEE
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	1	CIE/AAT/SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	CIE/AAT/SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	1	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

XI HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	3	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

XII MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	✓	✓	-	-	-	-	-	✓	-	-	✓	-	-
CO 2	✓	✓	✓	-	-	-	-	-	✓	✓	-	-	✓	-	-
CO 3	✓	✓	-	-	-	-	-	-	✓	✓	-	✓	✓	-	-
CO 4	✓	✓	-	-	-	-	-	-	-	✓	-		✓	-	-
CO 5	✓	✓	-	✓	-	-	-	-	-	✓	-	-	-	-	-
CO 6	✓	✓	✓	-	-	-	-	-	-	✓	-	-	✓	-	-

XIII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Recall** the knowledge of **mathematics,science and electrical engineering fundamentals** and apply them to calculate the resistance, inductance and capacitance of transmission lines.	3
	PO 2	**Identify** the type of tranmsiision line, Formulate the equations to calculate the transmission line parameters using the **first principles of mathematics, science and engineering.**	6
	PO 3	**Develop** the solutions for complex netwroks involving double ciruit lines, neighbouring communicaton system by effectively **designing** the tranmission system.	5
	PO 4	**Design** the ovehead tranmission line such that it will have no effect of neighbouring communicaton system	5
	PO 10	**Discuss** the concepts of inductance and capacitance of different types of transmission lines and prepare a PPT and present it.	3
	PSO 1	**Analyze** the types of overhead transmission line systems and **develop** the equations for transmission line inductance and capacitance using the concepts of GMR and GMD.	3
CO 2	PO 1	**Classify** the types of transmission lines based on the distance and define the performance parameters of lines using the **knowledge of science, engineering fundamentals.**	3
	PO 2	**Analyze** the performance parameters (efficiency and regulation) of lines using the ABCD constants using the first **principles of mathematics, and engineering sciences.**	6
	PO 3	**Develop** the mathematical **solutions** by mathematical **modeling** of transmission lines and solve **the complex engineering problems** related to these lines.	5
	PO 9	**Model** the transmission line system involving multiple lines with a team of members or individually.	4
	PO 10	**Discuss** the concepts tranmsission line modelling and performance of lines and prepare a PPT and present it.	3
	PSO 1	**Analyze** the performance of short, medium and long transmission lines using the ABCD constants and observe the Ferranti effect in transmission line system.	3
CO 3	PO 1	**Classify** the types of overhead insulators and calcualte the string efficiency by applying the **knowledge of science, engineering fundamentals.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	**Develop** the equations for determining the string efficiency in ovehead lines using the **principles of mathematics, science and engineering fundamentals.**	5
	PO 9	**Find** the string efficiecy of an insulator string with 3 or more discs by involvinh with a team of members or individually.	4
	PO 10	**Discuss**the concept string effficiency and methods for improving it and prepare a PPT and present it.	3
	PO 12	**Recognize** the need of caclcuating string efficiency and adapt it in real time for improving the votlage distribution in a string of insulators	3
	PSO 1	**Investigate** the methods available to increase the string efficiency or voltage distribution across a string of insulators and to increse the flexibility of tranmission system.	3
CO 4	PO 1	Know the insulation resistance, capacitance and dielectric stress of cables and from the basic **knowledge of science and engineering fundamentals.**	3
	PO 2	**Analyze** the dielectric stress in cables using the **principles of mathematics and engineering sciences.**	5
	PO 10	**Discuss**the concept of resistance, capacitance and dielectric stree of cables and prepare a PPT and present it.	3
	PSO 1	**Analyze** the underground cable operating parameters such as insulation resistance, capacitance and dielectric stress **suggest** the methods to get uniform dielectric stress in cable and to improve the power tranmission system.	2
CO 5	PO 1	**Define** the skin effect, proximity effect, Ferranti effect, corona effect, sag and tension from the **knowledge of science, engineering fundamentals.**	3
	PO 2	**Analyze** the surge impedance and surge impedance loading of lines, sag and tension under different weather conditions and also **identify the solutions** to minimize the skin effect, proximity effect, Ferranti effect and corona effect using the first **principles of mathematics, natural sciences, and engineering sciences.**	4
	PO 4	**Investigate** for voltage profile of the line at different loading conditions and suggest the methods to be adopted for improving the voltage profile	5
	PO 10	**Discuss**the the concepts of sag and tension in overhead lines and prepare a PPT and present it.	3
	PSO 1	**Design** a syttem for determing the ferrenti effect, surge impedance and surge impedance loading of the transmission line	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	PO 1	Understand the Indian electri grid scenario and the Indian Electricity rules by **using the knowledge of principles of science, mathematics and electrical engineering fundamentals.**	3
	PO 2	**Determine** the Voltage drop in AC and DC distributors using **the first principles of mathematics, science and engineering**	5
	PO 3	**Analyze** the indian electricity rules to design the distruibution system equipment in cost effective way and according the needs of utility companies	4
	PO 10	**Discuss**the the concepts of AC and DC distribution feeders, substations and voltage drop caluculations and prepare a PPT and present it.	3
	PSO 1	**Develop** the solutions for economic electric power distribution using the kelvins laws and examine the indian grid scenario.	2

XIV TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	6	5	5	-	-	-	-	-	3	-	-	3	-	-
CO 2	3	6	5	-	-	-	-	-	4	3	-	-	3	-	-
CO 3	3	5	-	-	-	-	-	-	4	3	-	3	3	-	-
CO 4	3	5	-	-	-	-	-	-	-	3	-	-	2	-	-
CO 5	3	4	-	5	-	-	-	-	-	3	-	-	3	-	-
CO 6	3	5	4	-	-	-	-	-	-	3	-	-	2	-	-

XV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	60	50	45.5	-	-	-	-	-	60	-	-	60	-	-
CO 2	100	60	50	-	-	-	-	-	33.3	60	-	-	60	-	-
CO 3	100	50	-	-	-	-	-	-	33.3	60	-	37.5	60	-	-
CO 4	100	50	-	-	-	-	-	-	-	60	-	-	40	-	-
CO 5	100	40	-	45.5		-	-	-	-	60	-	-	60	-	-
CO 6	100	50	40	-	-	-	-	-	-	60	-	-	40	-	-

XVI COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 - $5 < C \leq 40\%$ – Low/ Slight
2 - $40\ \% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	2	2	-	-	-	-	-	2	-		3	-	-
CO 2	3	3	2	-	-	-	-	-	1	2	-	-	2	-	-
CO 3	3	2	-	-	-	-	-	-	1	2	-	1	1	-	-
CO 4	3	2	-	-	-	-	-	-	-	2	-	-	2	-	-
CO 5	3	1	-	2	-	-	-	-	-	2	-		3		-
CO 6	3	2	1	-	-	-	-	-	-	2	-	-	2	-	-
TOTAL	18	13	5	4	-	-	-	-	2	12	-	1	11	-	-
AVERAGE	3.0	2.16	1.67	2.0	-	-	-	-	1.0	2.0	-	1.0	2.2	-	-

XVII ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	-				

XVIII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XIX SYLLABUS:

UNIT I	TRANSMISSION LINE PARAMETERS
	Transmission line parameters: Types of conductors, simple diagrams of typical towers and conductors for 400, 220 and 132 kV operations, calculation of resistance for solid conductors, calculation of inductance for single phase and three phase, single and double circuit lines, concept of GMR and GMD, symmetrical and asymmetrical conductor configuration with and without transposition, numerical problems, capacitance calculations for symmetrical and asymmetrical single and three phase lines, single and double circuit lines, effect of ground on capacitance, numerical problems; Corona: Types, critical disruptive voltages, factors affecting corona, methods for reducing corona power loss, charge voltage diagram, audible noise, radio interference.

UNIT II	**MODELING AND PERFORMANCE OF TRANSMISSION LINES**
	Classification of transmission lines: Short, medium and long line and their model representations, nominal T, nominal and A, B, C, D constants for symmetrical and asymmetrical networks, numerical problems, mathematical solutions to estimate regulation and efficiency of all types of lines, numerical problems; Long transmission line: Rigorous solution, evaluation of A, B, C, D constants, interpretation of the long line equations, methods of voltage control, Ferranti effect, incident, reflected and refracted waves, surge impedance and surge impedance loading of long lines, wave length and velocity of propagation of waves, representation of long lines, equivalent T and equivalent network model, numerical problems.
UNIT III	**OVERHEAD INSULATORS AND UNDERGROUND CABLES**
	Overhead insulators: Types of insulators, voltage distribution, string efficiency and methods for improvement, capacitance grading and static shielding, numerical problems. Underground cables: Types of cables, construction, types of insulating materials, calculations of insulation resistance and stress in insulation, capacitance of single and three core belted cables, grading of cables, capacitance grading, description of inter sheath grading, numerical problems.
UNIT IV	**MECHANICAL DESIGN OF TRANSMISSION LINES**
	Sag and tension calculations: Sag and tension calculations with equal and unequal heights of towers, effect of wind and ice on weight of conductor, stringing chart and sag template and its applications, numerical problems.
UNIT V	**DISTRIBUTION SYSTEMS**
	Distribution systems: Classification, comparison of DC vs AC and underground vs overhead, radial and ring main system, requirements and design features, Substation: Substation design, equipments, types of substations, bus bar arrangement layout, bus schemes, location, Kelvin's law for the design of feeders and its limitations; voltage drop calculations in DC distributors: Radial DC distributor fed at one end and at both the ends (equal / unequal voltages) and ring main distributor, voltage drop calculations in AC distributors, power factors referred to receiving end voltage and with respect to respective load voltages, numerical problems; Basic concept of interconnected systems: Indian electricity rules, various voltage levels of transmission and distribution systems, Indian grid scenario.

TEXTBOOKS

1. D P Kothari and I J Nagrath, "Power System Engineering", McGraw-Hill Education, 2nd Edition, 2007.

2. V K Mehta and Rohit Mehta, "Principles of Power System", S Chand, 3rd revised Edition, 2015.

3. D Das, "Electrical Power systems", New age international publishers, 2nd edition, 2006.

4. K R Padiyar, "HVDC transmission Systems", New age international publishers, 2nd edition, 2005.

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1. C L Wadhwa, "Electric Power Systems", New age publications, New Delhi, 9th Edition, 2007.
2. Turan Gonen, "Electrical Power Distribution System Engineering", CRC Press, 3rd Edition, 2014.
3. V Kamaraju, "Electrical Power Distribution Systems", TMH, Publication, Edition 2009.
4. Singh S N, "Electric Power Generation, Transmission and Distribution", Prentice Hall of India Pvt. Ltd., New Delhi, 2nd Edition, 2002.

XX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
	OBE DISCUSSION		
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	-
	CONTENT DELIVERY (THEORY)		
2	Introduction, Types of conductors	CO 1	T1: 2.1-2.5, R1:2.2- 2.8
3	Calculation of resistance for solid conductors, description and effect of resistance on solid conductors, skin effect and proximity effect	CO 1	T1: 2.11, R1:2.13
4	Calculation of inductance for single phase line	CO 1	T1: 2.3, R1:2.1-2.3
5	Calculation of inductance for three phase line	CO 1	T1: 2.4, R1:2.4
6	Single and double circuit lines, concept of GMR, GMD	CO 1	T1: 2.6, R1:2.5
7	Inductance of bundled conductors and double circuit transmission line	CO 1	T1: 2.7, R1: 2.11
8	Capacitance for 3 wire line symmetrical and asymmetrical line	CO 1	T1: 2.8, R1: 2.6-2.7
9	Capacitance for bundled conductor line and double circuit line.	CO 1	T1: 2.8, R1: 2.6-2.7
10	Effect of ground on capacitance	CO 1	T1: 2.9, R1: 2.10
11	Corona, description of the phenomenon, factors affecting corona, critical voltages and power loss	CO 2	T2:14.1-14.9, R1: 6.1 & 6.2
12	Radio interference, Electrostatic and electromagnetic interference with communication lines	CO 2	T3: 14.10, R1: 6.5 & 6.6
13	Classification of transmission lines, modeling, equivalent representation and performance of short lines	CO 5	T1: 5.1-5.2, R1: 4.1-4.2

14	Modeling of nominal –T and Nominal –Pie representation of medium lines.	CO 3	T1:5.3, R1: 4.3
15	Modeling and performance of long transmission line using rigorous solution	CO 3	T1:5.4, R1:4.4
16	Evaluation of ABCD constants of long lines, Equivalent-T and equivalent-Pie representation of long lines	CO 5	T1: 5.4, R1:4.5
17	Ferranti effect, charging current, effect on regulation of the transmission line	CO 4	T1:5.6, R1: 4.6
18	Surge impedance and SIL of long lines, wave length and velocity of propagation of waves.	CO 4	T1:5.5, R1:4.4
19	Overhead line insulators: properties, materials used and types of insulators	CO 5	T2: 8.4-8.5, R1: 81
20	String efficiency and methods for improvement	CO 6	T2: 8.6, R1: 8.2
21	Testing of insulators	CO 5	T2: 8.4-8.5, R1: 81
22	Underground cables: Construction, types of insulating materials	CO 5	T2: 11.1 -11.5, R1: 9.1&9.9
23	Types of cables	CO 2	T2: 11.1 -11.5, R1: 9.1&9.9
24	Calculation of insulation resistance and capacitance in insulation of a single core cable	CO 7	T2:11.7-11.10, R1: 9.4 & 9.5
25	Calculation of Dielectric stress on single core cables	CO 7	T2:11.7-11.10, R1: 9.4 & 9.5
26	Capacitance of 3-core belted cables	CO 7	T2:11.7-11.10, R1: 9.4 & 9.5
27	Grading of cables: description of capacitance grading and inter-sheath grading	CO 7	T2:11.11-11.13
28	Sag and tension calculations with equal and unequal heights of towers, Effect of wind and ICE on weight of conductor	CO 8	T2: 8.15& 8.16
29-30	Stringing chart, sag template and its applications, Mechanical design of typical towers and conductors for 400KV, 220KV and 132KV operations	CO 8	T2: 8.16, R1: 7.4&7.5
31	Distribution systems: Classification, comparison of DC vs AC and underground vs overhead	CO 9	T5:12.5-12.8, R1: 12.4
32	Radial and ring main system, requirements and design features	CO 9	T5:12.9-12.10, R1: 12.4
33	Substation: Substation design, equipments, types of substations, bus bar arrangement layout, bus schemes, location	CO 9	T5:12.12, R1: 12.4
34	Kelvin's law for the design of feeders and its limitations	CO 9	T5:12.15, R1: 12.5

35-37	Voltage drop calculations in DC distributors: Radial DC distributor fed at one end and at both the ends (equal / unequal voltages) and ring main distributor	CO 9	T5:12.13, R1: 12.4
38-39	oltage drop calculations in AC distributors, power factors referred to receiving end voltage and with respect to respective load voltages,	CO 9	T5:12.14, R1: 12.4
40	Basic concept of interconnected systems: Indian electricity rules	CO 10	R1:1.1 1-1.12
41	Various voltage levels of transmission and distribution systems, Indian grid scenario.	CO 10	R1:1.1 1-1.12
PROBLEM SOLVING/ CASE STUDIES			
42	Numerical Problems to calculate inductance of single phase and three phase line	CO 1	T1: 3.4, R1: 3.4
43	Numerical Problems to calculate inductance of bundled conductor line and double circuit line	CO 1	T1: 3.5, R1: 3.5
44	Numerical Problems to calculate capacitance of single phase and three phase line	CO 1	T1: 3.9, R1: 3.6
45	Numerical Problems to calculate capacitance of bundled conductor line	CO 1	T1: 3.7, R1: 3.7
46	Numerical Problems to calculate capacitance of double circuit line	CO 1	T1: 3.1-3.7, R1: 3.1-3.7
47	Numerical Problems on corona	CO 2	T2: 14.1-14.10, R1: 6.1-6.6
48	Numerical problems to evaluate performance of short and medium transmission lines	CO 3	T1:5.1-5.3, R1:4.1-4.3
49	Numerical problems to evaluate performance of long lines	CO 3	T1:5.1-5.3, R1:4.1-4.3
50	Problems on Ferranti effect, surge impedance and SIL of long lines	CO 4	T1: 5.4 -5.10, R1:4.4-4.6
51	Numerical problems to calculate string efficiency	CO 6	T2: 8.7, R1: 8.2
52	Numerical problems on resistance, capacitance of cables	CO 7	T2: 11.7-11.10, R1: 9.1-9.5
53	Numerical problems on dielectric stress of cables	CO 7	T2: 11.7-11.10, R1: 9.1-9.5
54	Numerical problems on grading of cables	CO 7	T2:11.11-11.13
55	Numerical problems to calculate sag and tension claulation for supports at equal levels	CO 8	T2: 8.4-8.7, R1: 8.1-8.2
56	Voltage drop calculations in AC and DC distribution feeders	CO 9	T2: 8.4-8.7, R1: 8.1-8.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Skin effect, Proximity effect, inductive reactance spacing factor, transposition of lines	CO 4	T1: 2.1-2.10

58	Propagation constant, characteristic impedance, surge impedance and surge impedance loading, wave length, velocity of propagation of waves	CO 4	T1: 5.1-5.7
59	String efficiency, safety factor of insulators, sag and tension on lines, sag template, stringing chart	CO 6	T2: 8.4-8.7
60	Insulation resistance, dielectric stress, capacitance grading, inter sheath grading	CO 7	T2:11.1-11.13
61	Distributio system classification, substation equipment, indian grid scenario	CO 10	T5:12.1-12.14
DISCUSSION OF QUESTION BANK			
62	UNIT I: Transmission line parameters	CO 1	T1: 2.1-2.10
63	UNIT II:Modeling and performance of transmission lines	CO 3	T1: 5.1-5.7
64	UNIT III: Overhead Insulators and underground Cables	CO 5	T2: 8.4-8.7
65	UNIT IV: Mechnaical design of tranmsision lines	CO 8	T5:12.1-12.14
66	UNIT V: Distribution Systems	CO 9	T2:11.1-11.13

Signature of Course Coordinator **HOD,EEE**

Mr. P Mabuhussain, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**

PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**

PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**

PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**
PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**
PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer. 1. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Industrial Automation and Control**				
Course Code	AEE511				
Program	B.Tech				
Semester	V				
Course Type	Professional Elective				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3		3	-	-
Course Coordinator	Dr. M Pala Prasad Reddy, Associate Professor				

I COURSE OVERVIEW:

This course provides an exposure to technology of industrial automation and control as widely seen in across a range of industries. It contains a wide range of topics from the advantages and architecture of automation systems, measurement systems including sensors and signal conditioning, discrete and continuous variable control systems, programmable logic controllers, CNC machines and actuators.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE008	IV	Electrical Measurements and Instrumentation
B.Tech	AEE009	IV	Control Systems

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Microprocessors and Microcontrollers	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage

in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
50 %	Understand
50 %	Apply
0 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

VI COURSE OBJECTIVES:

The students will try to learn:

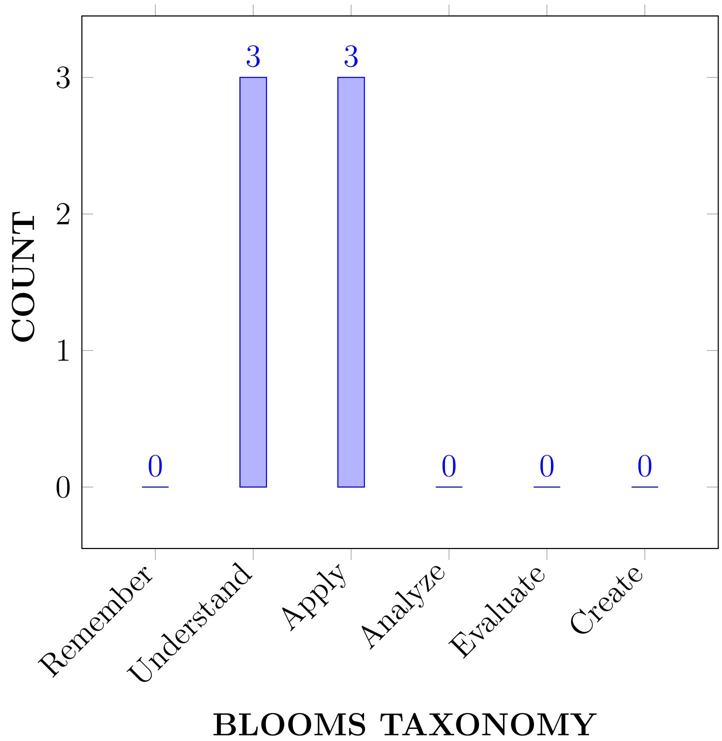
I	The functionality of the basic elements of industrial automation systems and the fundamental principles of operation of numerous instruments and machines.
II	The various control techniques employed in process automation including programmable logic controllers.
III	The substantial applications of automation systems and analyze real-life problems from an automation perspective based on engineering and cost-oriented thinking.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Illustrate** the architecture of automation system and its hierarchical levels for supervisory control of an industrial process.	Understand
CO 2	**Demonstrate** the operating principles of various instruments instruments for measuring variables in a controlled process.	Understand
CO 3	**Identify** the suitable control technique to control a given process for achieving desired response.	Apply
CO 4	**Makeuse of** PLC's in hardware and software environment and ladder logic for Automatic control of an industrial application.	Apply
CO 5	**Demonstrate** the principle of operation of CNC machines, control valves and actuators to perform various operations in an industrial application.	Understand
CO 6	**Choose** an appropriate electric driver for an industrial application based on drive characteristics.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

	Program Outcomes
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Program Outcomes	
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	AAT
PO 6	**The Engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	AAT
PO 7	**Environment and Sustainability:** Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	1	AAT
PO 9	**Individual and Teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	1	AAT
PO 10	**Communication:** Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	AAT
PO 12	**Life - Long Learning:**Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Build embedded software and digital circuit development platform for robotics, embedded systems and signal processing applications.	3	AAT

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	✓	✓	✓	✓	-	✓	-	-	✓	✓	-	✓	-	-	✓
CO 2	✓	✓	✓	-	-	-	-	-	-	✓	-	-	-	-	✓
CO 3	✓	✓	✓	✓	-	-	-	-	✓	✓	-		-	-	✓
CO 4	✓	✓	✓	✓	-	✓	-	-	-	✓		✓	-	-	✓
CO 5	✓	✓	✓	✓	-	✓	-	-	✓	✓	-	-	-	-	✓
CO 6	✓	✓	✓	✓	-	-	-	-	-	-	-		-	✓	✓

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Identify **(knowledge)** the various components of automation systems and understand their role in automating the complex industrial processes by **applying the knowledge of mathematics and science and engineering fundamentals.**	3
	PO 2	Understand the **problems** associated with manual control and build automated systems by selecting appropriate devices to achieve **automatic control** and interpret the results for increased productivity.	5
	PO 3	Understand the requirements of supervisory control in industrial applications and **Identify the limitations** in existing systems, **use creativity** in applying the automation techniques to provide **innovative solutions**. **Evaluate the outcomes** of the automated process **and understand the economic context.**	3
	PO 4	Recognize (knowledge) the characteristics of various industrial processes without automation (context) ; understand the principles of industrial automation system and apply it to control a complex process.	3
	PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health and safety issues and the consequent responsibilities relevant to the automation of processes with professional engineering practice	3
	PO 9	Function effectively in automating an industry or process as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	5
	PO 10	Communicate effectively with the Engineering community while configuring the industry in automation perspective and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 12	Recognize the need of automation in daily activities and enhance the functionality with new and cutting edge technologies to engage in independent job role and as a life-long learning.	6
	PSO 3	Understand the various modules of automation systems used for measuring, modifying and transforming the information with the help of necessary software/hardware tools.	4
CO 2	PO 1	Identify **(knowledge)** the need of measuring instruments at various levels in performing the automation and understand their role in measuring complex quantities of industrial processes by **applying the knowledge of mathematics and science and engineering fundamentals.**	3
	PO 2	Understand the requirements of measuring instruments for supervisory control in industrial applications and **Identify the limitations** of manual measurement, **use creativity** in selecting instruments to provide **innovative solutions**. **Evaluate the outcomes** of the automated process and **understand the economic context.**	5
	PO 3	Understand the requirements of measuring instruments for supervisory control in industrial applications and **Identify the limitations** of manual measurement, **use creativity** in selecting instruments to provide **innovative solutions**. **Evaluate the outcomes** of the automated process and **understand the economic context.**	5
	PO 10	Communicate effectively with the Engineering community while installing the various instruments in automation perspective and write effective reports and design documentation for further inspections and communication	3
	PSO 3	Make use of measuring instruments with appropriate **software integration** for transforming and measurement of data in an industrial application.	4
CO 3	PO 1	Identify **(knowledge)** the need of controllers at various levels in performing the automation and understand their role in controlling complex industrial processes by **applying the knowledge of mathematics and science and engineering fundamentals.**	3
	PO 2	Understand the **problems** associated in achieving desired response of a process and use advanced control techniques and tuning methods to achieve precise **control** and interpret the results for accuracy.	5

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 3	Investigate the problems in achieving precise control of an automated process and **Identify the limitations on controllers** and **use creativity** in selecting controllers to provide **solutions**. **Evaluate the performance** of a process using various controllers to understand the accuracy in precise control.	4
	PO 4	Recognize (knowledge) the characteristics of controllers (context) ; understand the principles of industrial automation system and apply the control techniques to control a complex process	4
	PO 9	Function effectively in automating an industry or process as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	5
	PO 10	Communicate effectively with the Engineering community while configuring the industry in automation perspective and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	3
	PSO 3	Develop programming skills in tuning and designing controllers using various tools at various levels of automation and analyze the performance.	4
CO 4	PO 1	Identify **(knowledge)** the different ways of programming PLC's in automation applications and understand their role in controlling complex industrial processes by **applying the knowledge of mathematics and science and engineering fundamentals.**	3
	PO 2	Identify the **problems** of using manual control in industrial process and use different techniques of programming programmable logic controllers to achieve precise control, increased productivity and other benefits in any automation applications.	4
	PO 3	Investigate the problems in achieving precise control of an automated process and **use creativity** in programming the PLC's. **Evaluate the performance** of an automated process for increased flexibility in control and economic growth.	4
	PO 4	**Recognize (knowledge) the characteristics** of various industrial processes with logic controllers; understand the corresponding **context of the engineering knowledge related** to the performance indicators and measures, **technical uncertainty** of the process and specific quantities causing the variations in the performance of automated applications.	4
	PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health and safety issues and the consequent responsibilities relevant to the automation of processes using programmable logic controllers with professional engineering practice	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 10	Communicate effectively with the Engineering community while configuring the industry using programmable logic controllers and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	3
	PO 12	Recognize the need of programmable logic controllers in daily activities and enhance the functionality with new and cutting edge technologies to engage in independent job role and as a life-long learning.	5
	PSO 3	Develop the ability to program logic controllers and work in an automated industrial environment	3
CO 5	PO 1	Identify **(knowledge)**the necessity of computer numerical control machines, actuators and control valves in automation applications and understand their role in complex industrial processes for machining operations by **applying the knowledge of mathematics and science and engineering fundamentals.**	3
	PO 2	Identify **(knowledge)**the necessity of computer numerical control machines, actuators and control valves in automation applications and understand their role in complex industrial processes for machining operations by **applying the knowledge of mathematics and science and engineering fundamentals.**	3
	PO 3	Investigate the problems in making fine products with conventional machinery and use creativity in providing solutions with the usage of CNC machines for increasing the accuracy and productivity. Evaluate the accuracy of end products in an automated process with CNC operations	3
	PO 4	Recognize (knowledge) the characteristics of various machinery used in industrial processes (context) ; understand the principles and program them using available tools to perform complex tasks.	3
	PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health and safety issues and the consequent responsibilities relevant to the automation of processes using CNC machines with professional engineering practice	3
	PO 9	Function effectively in automating an industry or process using CNC machines as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	5
	PO 10	Communicate effectively with the Engineering community while configuring the industry using programmable logic controllers and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 3	Gain the hands-on skills to work with CNC machines, actuators and control valves and program them using appropriate tools to perform various machining operations in an industrial process.	4
CO 6	PO 1	Identify **(knowledge)** the necessity of electric drives in automation applications and understand their role in complex industrial processes to perform various operations by **applying the knowledge of mathematics and science and engineering fundamentals.**	3
	PO 2	Identify the **problems** of using electric drives in industrial process for various operations and select suitable drive for an industrial application.	4
	PO 3	Investigate the problems in achieving efficiency while operating various units with drives in automated process and **use creativity** in selecting suitable drives with appropriate control strategy.	4
	PO 4	Recognize (knowledge) the characteristics of electrical drives used in industrial processes (context) ; understand the principles and configure them to perform complex tasks. .	4
	PSO 2	Examine the necessity of various electric drives in energy conversion and management while automating a process for economic growth and sustainable rural development.	5
	PSO 3	Apply the knowledge to integrating electric drives in software environments with PLC's and HMI for industrial applications.	4

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	3	5	3	3	-	3	-	-	5	3	-	6	-		4
CO 2	3	5	5	-	-	-	-	-	-	3	-	-	-	-	4
CO 3	3	5	4	4	-	-	-	-	5	3-	-	-	-	-	4
CO 4	3	4	4	4	-	2	-	-	-	3	-	5	-		4
CO 5	3	3	3	3-	-	3	-	-	5	3	-	-	-	-	4
CO 6	3	4	4	4	-	-	-	-	-	-	-		-	5	4

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	100	50	30	28	-	60	-	-	42	60	-	50	-	-	57
CO 2	100	50	50	-	-	-	-	-	-	30	-	-	-	-	57
CO 3	100	50	30	-	-	-	-	-	-	-	-	-	-	-	57
CO 4	100	40	40	37	-	40	-	-	-	30	-	50	-	-	57
CO 5	100	40	30	28	-	60	-	-	42	30	-	-	-	-	57
CO 6	100	40	40	37	-	-	-	-	-	-	-		-	45	57

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	2	1	-	2	-	-	2	2	-	2	-	-	2
CO 2	3	2	2	-	-	-	-	-	-	2	-	-	-	-	2
CO 3	3	2	1	1	-	-	-	-	2	2	-	-	-	-	2
CO 4	3	1	1	1	-	2	-	-	-	2	-	2	-	-	2
CO 5	3	1	1	1	-	2	-	-	2	2	-	-	-	-	2
CO 6	3	1	1	1	-	-	-	-	-	-	-		-	1	2
TOTAL	18	10	8	5	-	6	-	-	6	8	-	4	-	1	12
AVERAGE	3	2	1	1	-	1	-	-	1	1	-	1	-	1	2

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	-
Quiz	-	Tech - Talk	✓	Certification	-
Term Paper	-	Seminars	-	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	✓	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
✓	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts		

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO INDUSTRIAL AUTOMATION AND CONTROL**
	Introduction to Industrial Automation and Control: Introduction to industrial automation and control architecture of industrial automation system, measurement systems specifications, temperature measurement, pressure and force measurement, displacement and speed measurement, signal conditioning circuits, errors and calibration.
MODULE II	**PROCESS CONTROL**
	Process control: Introduction to process control, PID control, controller tuning, implementation of PID controllers, special control structures, feed forward and ratio control special control structures: predictive control, control of systems with inverse response.
MODULE III	**PROGRAMMABLE LOGIC CONTROL SYSTEMS**
	Programmable logic control systems: introduction to sequence or logic control and programmable logic controllers, the software environment and programming of PLCs, formal modeling of sequence control specifications. Programming , programming of PLCs: sequential function charts, the PLC hardware environment
MODULE IV	**CNC MACHINES AND ACTUATORS**
	CNC machines and actuators: Introduction to computer numerically controlled machines, control valves, hydraulic actuation systems, principle and components, directional control valves, switches and gauges, industrial hydraulic circuits.
MODULE V	**ELECTRICAL MACHINE DRIVES**
	Electrical machine drives: Energy savings with variable speed drives, step motors: principles, construction and drives, electrical actuators, DC motor drives, electrical actuators: induction motor drives, electrical actuators, BLDC motor drives.

TEXTBOOKS

1. Madhu Chanda Mitra, Samarjit Sen Gupta, "Programmable Logic Controllers and Industrial Automation: An Introduction", Penram International Publishing (India) Pvt. Ltd., 1 st Edition, 2008.

2. K Krishnaswamy, S Vijayachitra, "Industrial Instrumentation", New Age Publications, 1 st Edition, 2010.

3. Rajesh Mehra, Vikrant Vij, PLCs & SCADA: Theory and Practice, Laxmi publications, 2nd Edition, 2016

REFERENCE BOOKS:

1. AK Gupta, S K Arora, "Industrial Automation and Robotics", Laxmi Publications, 2nd Edition, 2013.

2. Jon Stenerson, “Industrial Automation and Process Control”, Prentice Hall, 1st Edition, 2002.

WEB REFERENCES:

1. https://nptel.ac.in/courses/108105088
2. https://www.iare.ac.in/?q=pages/btech-course-descriptions-iare-r18-1

COURSE WEB PAGE:

1. https://lms.iare.ac.in/index?route=course/details&course_id=135

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	https://lms.iare.ac.in/index?route=course/details&course_id=135
CONTENT DELIVERY (THEORY)			
2	Role of automation in industries	CO 1	T1: 1.1 – 1.5
3	Architecture of Industrial Automation Systems	CO 1	T1: 1.1 – 1.5
4	Measurement system characteristics	CO 2	T3: 1.1.1 – 1.1.2
5	Measurement Systems Specifications	CO 2	T3: 1.3.1
6	Temperature measurement	CO 2	T3: 1.3.3
7	Pressure Measurement	CO 2	T3: 1.3.2 - 1.3.4
8	Force measurement	CO 2	T3: 1.3.8
9	speed and displacement measurement	CO 2	T3: 2.1 – 2.4
10	Signal conditioning circuits	CO 2	T3: 5.2
11	Data acquisition systems	CO 2	T3: 5.7
12	Errors in instruments	CO 2	T3: 5.7
13	Calibration of instruments	CO 2	T3: 5.7
14	Introduction to Automatic Control	CO 3	T3: 5.7
15	PID controller	CO 3	T1: 9.1 -9.4
16	Controller tuning methods	CO 3	T1: 9.1 -9.4
17	Implementation of controllers	CO 3	T1: 9.1 -9.4
18	Special control structures	CO 3	T1: 9.1 -9.4
19	Feed forward and ratio control	CO 3	T1: 9.1 -9.4
20	Predicative control	CO 3	T1: 9.1 -9.4
21	Systems with inverse response	CO 3	T1: 6.2 – 6.3
22	Applications of industrial automation in process industries	CO 3	T1: 3.1 – 3.8

23	Case studies	CO 3	T1: 3.1 – 3.8
26	Introduction to Sequence Control	CO 4	T1: 7.1 – 7.5
27	Programmable logic control	CO 4	T1: 7.1 – 7.5
28	Programming techniques for PLC	CO 4	T1: 7.1 – 7.5
29	Sequence Control. Scan Cycle, Simple RLL Programs	CO 4	T1: 7.2 -7.4
30	Sequence Control. More RLL Elements, RLL Syntax	CO 4	T1: 7.2 -7.4
31	Structured Design Approach to Sequence Control	CO 4	T1: 7.2 -7.4
32	Sequential flow charts	CO 4	T1: 6.1 – 6.10
33	State machine models	CO 4	T1: 6.1 – 6.10
34	Design of relay ladder logic for various problems	CO 4	T1: 5.7
35	PLC Hardware Environment	CO 4	T1: 5.7
44	Introduction to computer numerically controlled machines	CO 5	T1: 5.7
45	Contour generation and motion control	CO 5	T1: 2.2
46	CNC machining operations	CO 5	T1: 2.3
47	Basics of part programming	CO 5	T1: 5.7
48	Flow control valves	CO 5	T2: 2.1 - 2.4
49	Hydraulic control systems	CO 5	T2: 2.1-2.4
50	Industrial hydraulic circuit	CO 5	T2: 3.2
51	Pneumatic control system	CO 5	T2: 3.2.3
54	Energy savings with variable speed drives	CO 6	T2: 3.2.1
55	DC motor drives	CO 6	T2: 3.2.1
56	DC and BLDC servo drive	CO 6	T2: 3.2.2
57	Induction motor drives	CO 6	T2: 3.2.3
58	Step motor drives	CO 6	T2: 3.2.2
PROBLEM SOLVING/ CASE STUDIES			
14	Automation in cement industry	CO 1	T1:1.1 R2:1.1
15	Automated Welding Robots for Cars	CO 1	T1:3.4 R2:4.7
16	Industrial stamping process	CO 1	T1:3.4 R2:4.7
24	Effect of P, PI controllers	CO 3	T1:3.4 R2:4.1
25	Effect of PD and PID controllers	CO 3	T1:3.4 R2:4.4,4.5
36	RLL for 24 hours clock	CO 4	T1:5.1 R2:12.2,12.3
37	RLL for star-delta operation of dc motor drive	CO 4	T1:5.2 R2:12.4
38	Timer RLL diagrams	CO 4	T1:5.6,5.7 R2:9.8,9.9
39	RLL for DOL starter	CO 4	T1:5.8 R2:9.11

40	RLL for counter operationr	CO 4	T1:6.2 R2:10.3,10.4
41	Sequence control program for the industrial stamping process	CO 4	T1:6.3 R2:10.2
42	Design of RLL for industrial stamping process	CO 4	T1:6.4 R2:11.3
43	Industrial Logic Control using SFC	CO 4	T1:17.8 R2:19.3
52	Metal cutting through CNC machine	CO 5	T1:17.6 R2:20.2
53	The Fluid Delivery Subsystem	CO 5	T1:17.9 R2:21.3
DISCUSSION OF DEFINITION AND TERMINOLOGY			
59	Introduction to industrial automation and control	CO 1, CO 2	T1, R2
60	Process control	CO 3	T1, R2
61	Programmable logic controllers	CO 4	T1, R2
62	CNC machines and actuators	CO 5	T1, R2
63	Electric machine drives	CO 6	T1, R2
DISCUSSION OF QUESTION BANK			
64	Introduction to industrial automation and control	CO 1, CO 2	T1, R2
65	Process control	CO 3	T1, R2
66	Programmable logic controllers	CO 4	T1, R2
67	CNC machines and actuators	CO 5	T1, R2
68	Electric machine drivesr	CO 6	T1, R2

Signature of Course Coordinator
Dr. M Pala Prasad Reddy **HOD, EEE**

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences **(Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations **(Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**

PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**

PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**

PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**
PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043
ELECTRICAL AND ELECTRON ICS ENGINEERING
COURSE DESCRIPTION

<table>
<tr><td>Course Title</td><td colspan="5">POWER ELECTRONICS AND SIMULATION LABORATORY</td></tr>
<tr><td>Course Code</td><td colspan="5">AEE108</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td>V</td><td colspan="4">EEE</td></tr>
<tr><td>Course Type</td><td>Core</td><td colspan="4"></td></tr>
<tr><td>Regulation</td><td>IARE - R16</td><td colspan="4"></td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>3</td><td>2</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Mr. S. Srikanth, Assistant Professor</td></tr>
</table>

I COURSE OVERVIEW:

This course is intended for practical experience by conducting experiments on rectifiers, inverters, choppers, AC voltage controllers and cycloconverters. It provides hands-on experience by examining the electrical characteristics of various power converters. The power electronic converter applications have been analyzed with simulation tools.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECB04	III	Analog and Digital Electronics Laboratory

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Power Electronics and Simulation Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	-
20 %	Analysis	-
20 %	Design	-
20 %	Conclusion	-
20 %	Viva	-

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
-	-	-	-	-	-

VI COURSE OBJECTIVES:

The students will try to learn:

I	The engineering skills by way of electrical circuit design with power electronic devices and components.
II	Simulation and testing the different power converter circuits using simulation tools.
III	The demonstration of basic power electronic circuits for developing complex power converter modules.

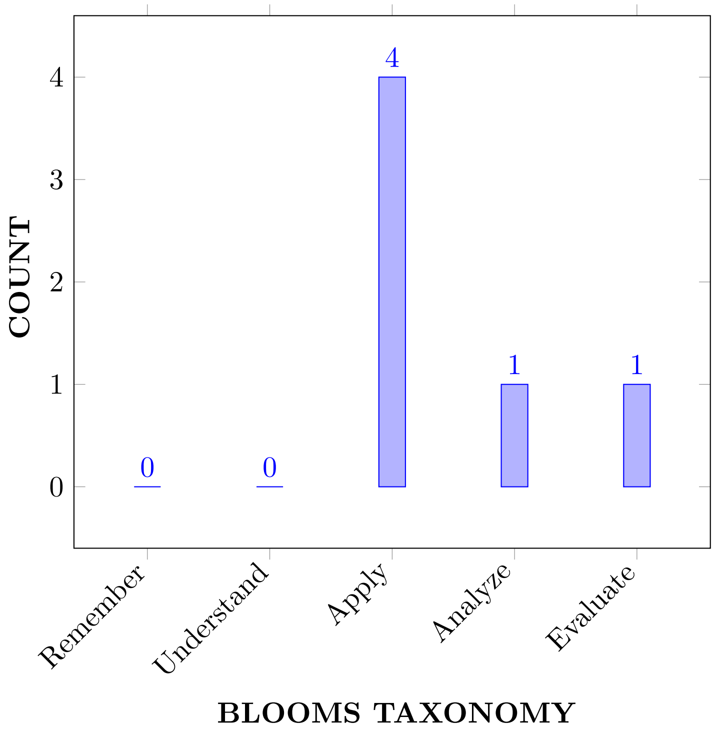
VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Experiment** the operation of SCR, MOSFET and IGBT for obtaining static voltage - current characteristics. .	Apply
CO 2	**Utilize** the forced commutation circuits and gate firing circuits for turning off and on of the SCR.	Apply

CO 3	**Analyze** the input and output waveforms of controlled rectifier circuits for determining the output voltages.	Analyze
CO 4	**Construct** the various inverter circuits for direct current to Alternating current conversion.	Apply
CO 5	**Determine** the performance characteristics of ac to ac converters for getting variable output voltage using hard ware and modern tools.	Evaluate
CO 6	**Develop** the chopper circuits for measuring output voltage and current .	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

Program Outcomes	
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	Lab Exercises
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3	Lab Exercises
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	Lab Exercises

PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	Lab Exercises
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	3	Lab Exercises
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Lab Exercises
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Lab Exercises
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	2	Lab Exercises
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	2	Lab Exercises
PSO 3	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Observe the functionality of power electronic components for static voltage current characteristics using **principles of mathematics and engineering science**	2
	PO 2	Understand the given power electronic components application **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the given power electronic components voltage current characteristics **for design solutions of complex engineering problems**	6
	PO 4	Understand the given power electronic components characteristics **with analysis and interpretation of data**	6
	PO 6	Illustrate the given power electronic component operation **for safety issues in professional engineering practice**	4
	PO 8	Understand the given power electronic components characteristics **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the given power electronic components operation **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the power electronic components operation **with communication of complex engineering practices**	3
	PO 12	Understand the given power electronic components application **in life long learning in technological change**	6
	PSO 1	Demonstrate the given power electronic components application **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the given power electronic components application **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the given power electronic components application **in automation process using PLC and process controllers**	4

CO 2	PO 1	Observe the functionality of forced commutation circuits and gate firing circuits using **principles of mathematics and engineering sciences**	2
	PO 2	Understand the forced commutation circuits and gate firing circuits with**problem statement by analyzing complex engineering problems.**	6
	PO 3	Develop the forced commutation circuits and gate firing circuits **for design solutions of complex engineering problems**	6
	PO 4	Understand the forced commutation circuits and gate firing circuits operation **with analysis and interpretation of data**	6
	PO 6	Illustrate the forced commutation circuits and gate firing circuits **for safety issues in professional engineering practice**	4
	PO 8	Understand the forced commutation circuits and gate firing circuits **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the forced commutation circuits and gate firing circuits **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the turn on and turn off methods of SCR **with communication of complex engineering practices**	3
	PO 12	Understand the forced commutation circuits and gate firing circuits **in life long learning in technological change**	6
	PSO 1	Demonstrate the forced commutation circuits and gate firing circuits **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the forced commutation circuits and gate firing circuits **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the forced commutation circuits and gate firing circuits **in automation process using PLC and process controllers**	4
CO 3	PO 1	Observe the input and output waveforms of controlled rectifier circuits using **principles of mathematics and engineering science**	2
	PO 2	Understand the operation of controlled rectifier circuits **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the controlled rectifier circuits **for design solutions of complex engineering problems**	6

	PO 4	Understand the input and output waveforms of controlled rectifier circuits **with analysis and interpretation of data**	6
	PO 5	Understand the controlled rectifier circuits **modelling using IT tools such as MATLAB**	6
	PO 6	Illustrate the input and output waveforms of controlled rectifier circuits **for safety issues in professional engineering practice**	4
	PO 8	Understand the input and output waveforms of controlled rectifier circuits **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the controlled rectifier circuits operation **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the input and output waveforms of controlled rectifier circuits **with communication of complex engineering practices**	3
	PO 12	Understand the controlled rectifier circuits operation **in life long learning in technological change**	6
	PSO 1	Demonstrate the input and output waveforms of controlled rectifier circuits **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the controlled rectifier circuits applications **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the operation of controlled rectifier circuits **in automation process using PLC and process controllers**	4
CO 4	PO 1	Observe the various inverter circuits for direct current to Alternating current conversion using **principles of mathematics and engineering science**	2
	PO 2	Understand the operation of various inverter circuits **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the inverter circuits **for design solutions of complex engineering problems**	6
	PO 4	Understand the various inverter circuits for direct current to Alternating current conversion **with analysis and interpretation of data**	6
	PO 5	Understand the inverter circuits **modelling using IT tools such as MATLAB**	6

	PO 6	Illustrate the various inverter circuits for direct current to Alternating current conversion **for safety issues in professional engineering practice**	4
	PO 8	Understand the various inverter circuits for direct current to Alternating current conversion **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the inverter circuits operation **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the various inverter circuits for direct current to Alternating current conversion **with communication of complex engineering practices**	3
	PO 12	Understand the inverter circuits operation **in life long learning in technological change**	6
	PSO 1	Demonstrate the operation of inverter circuits **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the inverter circuits applications **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the operation of inverter circuits **in automation process using PLC and process controllers**	4
CO 5	PO 1	Observe the performance characteristics of ac to ac converters using **principles of mathematics and engineering science**	2
	PO 2	Understand the operation of AC voltage controllers and cycloconverters **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the operation of AC voltage controllers and cycloconverters **for design solutions of complex engineering problems**	6
	PO 4	Understand the operation of AC voltage controllers and cycloconverters **with analysis and interpretation of data**	6
	PO 6	Illustrate the performance characteristics of ac to ac converters **for safety issues in professional engineering practice**	4
	PO 8	Understand the performance characteristics of ac to ac converters **with ethical principles, professional ethics and responsibilities**	2

	PO 9	Demonstarte the operation of AC voltage controllers and cycloconverters **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the operation of AC voltage controllers and cycloconverters **with communication of complex engineering practices**	3
	PO 12	Understand the AC voltage controllers and cycloconverters applications **in life long learning in technological change**	6
	PSO 1	Demonstrate the AC voltage controllers and cycloconverters applications **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the AC voltage controllers and cycloconverters applications **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the operation AC voltage controllers and cycloconverters applications **in automation process using PLC and process controllers**	4
CO 6	PO 1	Observe the chopper circuits operation using **principles of mathematics and engineering science**	2
	PO 2	Understand the operation of chopper circuits **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the chopper circuits **for design solutions of complex engineering problems**	6
	PO 4	Understand the various chopper circuits for dc to variable dc conversion **with analysis and interpretation of data**	6
	PO 5	Understand the chopper circuits **modelling using IT tools such as MATLAB**	6
	PO 6	Illustrate the chopper circuits for dc to varible dc conversion **for safety issues in professional engineering practice**	4
	PO 8	Understand the chopper circuits for dc to varible dc conversion **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the chopper circuits operation **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the the chopper circuits for dc to varible dc conversion **with communication of complex engineering practices**	3
	PO 12	Understand thechopper circuits operation **in life long learning in technological change**	6

	PSO 1	Demonstrate the operation of chopper circuits **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the chopper applications **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the operation of chopper circuits **in automation process using PLC and process controllers**	4

XII MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	3	3	-	2	-	3	2	2	-	2	2	3	3
CO 2	3	3	3	3	-	2	-	3	2	2	-	2	2	3	3
CO 3	3	3	3	3	3	2	-	3	2	2	-	2	2	3	3
CO 4	3	3	3	3	3	2	-	3	2	2	-	2	2	3	3
CO 5	3	3	3	3	-	2	-	3	2	2	-	2	2	3	3
CO 6	3	3	3	3	3	2	-	3	2	2	-	2	2	3	3

XIII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIV ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XV SYLLABUS:

WEEK I	**SCR, MOSFET AND IGBT**
	Study the characteristics of SCR, MOSFET and IGBT.
WEEK II	**GATE FIRING CIRCUITS**
	Study the operation of gate firing circuits of SCR.
WEEK III	**HALF CONTROLLED CONVERTER**
	Study the performance characteristics of single phase half controlled converter with R and RL loads.

WEEK IV	**FORCED COMMUTATION CIRCUITS**
	Plot the characteristics of forced commutation circuits (Class A, Class B, Class C, Class D and Class E).
WEEK V	**FULLY CONTROLLED BRIDGE CONVERTER**
	Study the characteristics of single phase fully controlled bridge converter with R and RL loads.
WEEK VI	**SERIES INVERTER**
	Study the characteristics of single phase series inverter with different loads.
WEEK VII	**PARALLEL INVERTER**
	Study the characteristics of single phase parallel inverter with different loads.
WEEK VIII	**VOLTAGE CONTROLLER**
	Plot the characteristics of Single phase AC voltage controller with R and RL loads.
WEEK IX	**DUAL CONVERTER**
	Study the characteristics of single phase dual converter with R and RL loads.
WEEK X	**CYCLOCONVERTER**
	Study the characteristics of single phase cycloconverter with R and RL loads.
WEEK XI	**THREE PHASE CONVERTERS**
	Plot the characteristics of three phase half converter with R and RL loads.
WEEK XII	**MOSFET BASED CHOPPERS**
	Study the principle of operation of step down chopper using MOSFET.
WEEK XIII	**SIMULATION OF THREE PHASE FULL CONVERTER AND PWM INVERTER**
	Simulation of three phase full converter and PWM inverter with R and RL loads by using MATLAB.
WEEK XIV	**SIMULATION OF BUCK – BOOST CHOPPER**
	Simulation of boost, buck, buck boost converter with R and RL loads by using MATLAB.

TEXTBOOKS

1. M D Singh, K B Kanchandhani, "Power Electronics", Tata Mc Graw Hill Publishing Company, 2nd Edition, 1998.
2. Dr. P S Bimbhra, "Power Electronics", Khanna Publishers, 5th Edition, 2012.

REFERENCE BOOKS:

1. Vedam Subramanyam, "Power Electronics", New Age International Limited, 2nd Edition, 2006.
2. G K Dubey, S R Doradra, A Joshi, R M K Sinha, "Thyristorised Power Controllers", New Age International Limited, 2nd Edition, 2008.
3. V R Moorthi, "Power Electronics Devices", Oxford University Press, 4th Edition, 2005.

XVI COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Study the characteristics of SCR, MOSFET and IGBT..	CO 1	T1:3.1
2	Study the operation of gate firing circuits of SCR..	CO 2	T1:3.11
3	Study the performance characteristics of single phase half controlled converter with R and RL loads.	CO 3	T1:4.8
4	Plot the characteristics of forced commutation circuits (Class A, Class B, Class C, Class D and Class E).	CO 2	T1:4.8
5	Study the characteristics of single phase fully controlled bridge converter with R and RL loads. .	CO 3	T1.5.5
6	Study the characteristics of single phase series inverter with different loads.	CO 4	T1:5.6
7	Study the characteristics of single phase parallel inverter with different loads..	CO 4	T1:8.3
8	Plot the characteristics of Single phase AC voltage controller with R and RL loads..	CO 5	T1:8.3
9	Study the characteristics of single phase dual converter with R and RL loads..	CO 3	T1:9.2
10	Study the characteristics of single phase cycloconverter with R and RL loads. .	CO 5	T1:9.3
11	Plot the characteristics of three phase half converter with R and RL loads..	CO 3	T1:10.6
12	Study the principle of operation of step down chopper using MOSFET.	CO 6	T1:10.7
13	Simulation of three phase full converter and PWM inverter with R and RL loads by using MATLAB.	CO 3	T1:10.7
14	Simulation of boost, buck, buck boost converter with R and RL loads by using MATLAB.	CO 6	T1:10.8

XVII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design three phase PWM inverters with digital simulation.
2	Design three phase AC voltage controller.
3	Design step up cycloconverter with digital simulation.
4	Design dual converter using digital simulation.

Signature of Course Coordinator **HOD, EEE**
Mr. S. Srikanth, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**

PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**

PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**

PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**
PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**
PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer. 1. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRONICS AND COMMUNICATION ENGINEERING**					
Course Title	**INTEGRATED CIRCUITS APPLICATIONS LABORATORY**					
Course Code	AEC106					
Program	B.Tech					
Semester	V	ECE				
Course Type	Core					
Regulation	IARE - R16					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	-	-	-	3	2	
Chief Coordinator	Ms M Sreevani, Assistant Professor					

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
B.Tech	AEC008	V	Integrated Circuits Applications	3

II COURSE OVERVIEW:

Linear and digital IC applications lab enables to learn design, testing and describing of circuit performance with digital and analog integrated circuits. It focuses on applications of special ICs and apply the techniques for the design of 741 ICs, applications of 555 timers, data converters and digital IC's for combination and sequential circuits design. This course provides practical hands-on experiments to analyze characteristics of commercially available digital integrated circuits.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Integrated Circuits Applications Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing Further Experiments

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the Principal from the panel of experts recommended by Chairman, BOS.
The emphasis on the experiments is broadly based on the following criteria:

20 %	To test the preparedness for the experiment.
20 %	To test the performance in the laboratory.
20 %	To test the calculations and graphs related to the concern experiment.
20 %	To test the results and the error analysis of the experiment.
20 %	To test the subject knowledge through viva – voce.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component	**Laboratory**		
Type of Assessment	**Day to day Performance**	**Final Internal Lab Assessment**	**Total Marks**
CIA Marks	20 Marks	10 Marks	30

Continuous Internal Examination (CIE):
One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

A. Experiment Based:

Preparation	**Performance**	**Calculations and Graph**	**Results and Error Analysis**	**Viva**	**Total**
2	2	2	2	2	10

VI HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Experiments / CIE / SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	Lab Experiments / CIE / SEE
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Lab Experiments / CIE / SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations.	3	Lab Experiments / CIE / SEE
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	Lab Experiments / CIE / SEE

3 = High; 2 = Medium; 1 = Low

VII HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 2	Focus on the Application Specific Integrated Circuit (ASIC) Prototype designs, Virtual Instrumentation and System on Chip (SOC) designs.	1	Lab Experiments / CIE / SEE

3 = High; 2 = Medium; 1 = Low

VIII COURSE OBJECTIVES:

The students will try to perform:

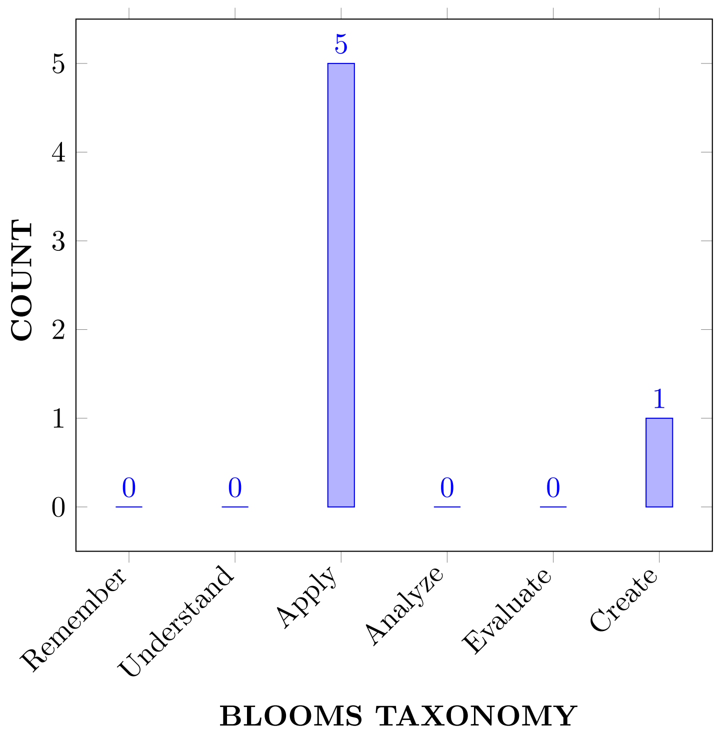
I	The experiments on design of Linear and Digital Integrated circuits using operational amplifier and digital ICs.
II	The design and implementation of analog circuits and gain the hands-on experience on the various building blocks of digital circuits.
III	The IC based real-time applications in the fields of communication systems and home-based automation systems.

IX COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO No	Course Outcomes	Knowledge Level (Bloom's Taxonomy)
CO 1	**Design** linear Integrated circuits to perform mathematical operations and voltage gain calculations using IC741.	Create
CO 2	**Plot** the frequency response of second order active filters using IC 741	Apply
CO 3	**Determine** the frequency of oscillations of multi-vibrators using IC741 and IC555 timer.	Apply
CO 4	**Obtain** the capture range and lock-in range of phase locked loop circuit using IC565.	Apply
CO 5	**Construct** the low and high voltage regulators to find the percentage of regulation using IC723.	Apply
CO 6	**Implement** combinational and sequential circuits using digital ICs to verify their functionality.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



X JUSTIFICATIONS FOR CO – PO / PSO) MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies matched.
CO 1	PO 1	**(Recall)** the basic function of transistor , importance of differential amplifier and the characteristics by applying the **own engineering discipline, science principles and methodology.**	2
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems of improving dc, ac characteristics of an operational, **translate the information** into the model from the **provided information and data, develop solutions** as compensation techniques ,**validate** the frequency response , stability of the circuit by the **interpretation of results.**	7
	PO 4	**Analyze and interpret** the design of linear Integrated circuits to perform mathematical operations and voltage gain calculations.	2
	PO5	**Create, select and apply appropriate techniques** to design the linear Integrated circuits to perform mathematical operations and voltage gain calculations.	3
	PO9	To improve the performance of team effectively in the classroom periods, in the hands-on labs and in the design projects to design linear integrated circuits .	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies matched.
CO 2	PO 1	**Explain** the importance of feedback and realize linear and non linear circuits using op-amp and the application of that model using **own engineering discipline, scientific principles and methodology.**	2
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems of applications of op-amp, **translate the information** into the model using IC741 from the provided **information and data, develop solutions**based on the functionality of the circuit,**validate** the output of the circuit in reaching substantiated conclusions by the **interpretation of results.**	7
	PO 4	**Analyze and interpret** the frequency response of active filter circuits to calculate different time constants.	2
	PO5	**Create, select and apply appropriate techniques** to find the frequency response of active filter circuits to calculate different time constants.	3
	PO9	To improve the performance of team effectively in the classroom periods, in the hands-on labs and in the design projects by Analyzing the frequency selective circuits.	2
	PSO 2	**Speaks fluently** about the importance of feeback and applications of operational amplifier**(Subject matter)**.	2
CO 3	PO 1	**Explain** the importance of IC 555 timer,voltage regulators and realize multivibrator circuits using IC 555 and the application of that model using **own engineering discipline, scientific principles and methodology.**	2
	PO 2	**Interpret**frequency of oscillations, pulse width and able to change these parameters based on **information and data collection , model translation and validate using experimental design.**	4
	PO 4	**Analyze and interpret** the frequency of oscillations of multi-vibrators using IC741 and IC555 timer circuits.	2
	PO5	**Create, select and apply appropriate techniques** to calculate the frequency of oscillations of multi-vibrators using IC741 and IC555 timer circuits.	3
	PO9	To improve the performance of team effectively in the classroom periods, in the hands-on labs and in the design projects to calculate the frequency of oscillations of multi-vibrators using IC741 and IC555 timer circuits.	2

Course Outcomes	**PO'S PSO'S**	**Justification for mapping (Students will be able to)**	**No. of Key Competencies matched.**
	PSO 2	**Apply** data converters in the field of application specific integrated circuit (ASIC) prototype designs and system on chip (SOC) designs.	1
CO 4	PO 1	**Demonstrate** different data converters for converting analog data to digital data and vice versa **applying basic knowledge of science and engineering fundamentals.**	2
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems of data converters, **translate the information** into the model and prototype systems from the provided **information and data, develop solutions** based on the functionality of the data translation, **validate** the data converters in reaching substantiated conclusions by the **interpretation of results**.	7
	PO 4	**Analyze ans interpret** the capture range and lock-in range of phase locked loop circuit using IC565.	2
	PO5	**Create, select and apply appropriate techniques** to find the capture range and lock-in range of phase locked loop circuit using IC565.	3
	PO9	To improve the performance of team effectively in the classroom periods, in the hands-on labs and in the design projects to find the capture range and lock-in range of phase locked loop circuit using IC565.	2
	PSO 2	**Apply** data converters in the field of application specific integrated circuit (ASIC) prototype designs and system on chip (SOC) designs.	1
CO 5	PO 1	**Build** digital logical design using digital ICs with the **knowledge of mathematics, science and engineering fundamentals.**	2
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems of digital system design , **translate the information** into the model and prototype systems from the provided **information and data, develop solutions** digital design using equipment, **validate** the design in reaching substantiated conclusions by the **interpretation of results**.	7
	PO 4	**Analyze and interpret** the low and high voltage regulators to find the percentage of regulation using IC723.	2
	PO5	**Create, select and apply appropriate techniques** to design the low and high voltage regulators to find the percentage of regulation using IC723.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies matched.
	PO9	To improve the performance of team effectively in the classroom periods, in the hands-on labs and in the design projects to design the low and high voltage regulators to find the percentage of regulation using IC723.	3
CO 6	PO 1	**Build** digital logical design using digital ICs with the **knowledge of mathematics, science and engineering fundamentals.**	2
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems of digital system design , **translate the information** into the model and prototype systems from the provided **information and data, develop solutions** digital design using equipment, **validate** the design in reaching substantiated conclusions by the **interpretation of results**.	7
	PO5	**Create, select and apply appropriate techniques** to verify the functionality of digital logic circuits.	3
	PO9	To improve the performance of team effectively in the classroom periods, in the hands-on labs and in the design projects to verify the functionality of digital logic circuits.	3
	PSO 2	**Design**, various digital circuits in application secific integrated circuit (ASIC) and system on chip (SOC) designs.	1

XI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1, PO 2	SEE Exams	PO 1, PO 2, PO 5	Seminars	PO1, PO12	Assignments	-
Laboratory Practices	PO 2, PO 3, PO 5	Student Viva		Mini Project	-	Certification	
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-	-	-

XII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIII MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE	PROGRAM OUTCOMES					PSO'S
OUTCOMES	PO 1	PO 2	PO 4	PO 5	PO 9	PSO 2
CO 1	2	7	2	3	2	-
CO 2	2	7	2	3	2	2
CO 3	2	4	2	3	2	1
CO 4	2	7	2	3	3	1
CO 5	2	7	2	3	3	-
CO 6	2	7	-	3	3	1

XIV SYLLABUS:

Week-1	**INVERTING, NON-INVERTING AND DIFFERENTIAL AMPLIFIERS**
	To construct and test the performance of an Inverting, Non-inverting amplifier and Differential amplifier using IC 741.
Week-2	**INTEGRATOR AND DIFFERENTIATOR**
	To construct and test the performance of an Integrator and Differentiator using IC 741.
Week-3	**SECOND ORDER ACTIVE LOWPASS, HIGHPASS AND BANDPASS FILTERS**
	To design and verify the operation of the Active low pass and High pass using IC 741.
Week-4	**ASTABLE MULTIVIBRATORS AND SCHMITT TRIGGER USING 555**
	To design and construct an Astable multivibrators and Schmitt trigger using IC 555.
Week-5	**MONOSTABLE MULTIVIBRATORS 555**
	To design and construct Monostable multivibrators using IC 555 .
Week-6	**SCHMITT TRIGGER USING 555**
	To design and construct schimitt trigger using NE555 Timer.
Week-7	**PLL USING IC 565**
	Verifying characteristics of PLL
Week-8	**INSTRUMENTATION AMPLIFIER.**
	To design and verify the operation of instrumentation amplifier using IC 741.
Week-9	**MULTIPLEXER AND DEMULTIPLEXER**
	Verify Functionality of multiplexer and demultiplexer.
Week-10	**ENCODER AND DECODER**
	Verify Functionality of encoder and decoder.
Week-11	**REALISATION OF DIFFERENT FLIP-FLOPS USING LOGIC GATES**
	Verify Functionality of flip-flop.
Week-12	**4 BIT COUNTERS**
	Verify Functionality of counters.
Week-13	**REALISATION OF SHIFT REGISTERS**
	Verify Functionality of shit register
Week-14	**DECADE COUNTER**
	Verify Functionality of decade counter

TEXTBOOKS

1. D. Roy Chowdhury, “Linear Integrated Circuits”, New age international (p) Ltd, 2nd Edition,2003
2. Ramakanth A. Gayakwad, “Op-Amps & linear ICs”, PHI, 3rdEdition,2003.
3. John F. Wakerly, “Digital Design Principles and Practices”, Prentice Hall, 3rdEdition,2005.

REFERENCE BOOKS:

1. Salivahanan, “Linear Integrated Circuits and Applications”, TMH, 1st Edition, 2008

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Week No	**Topics to be covered**	**CO's**	**Reference**
1	To find voltage gain of inverting, Non-inverting and Differential Amplifiers using IC 741.	CO 1	T1:11.1-11.5
2	To find the frequency response of integrator and differentiator for different inputs using IC741.	CO 1	T1:11.1-11.5
3	To find the frequency response of second order Active Lowpass, High-pass And Bandpass Filters using IC 741.	CO 2	T1:4.8 , T1:7.2
4	To design and construct an Astable multivibrators and Schmitt trigger using IC 555.	CO 2	T1:4.8 , T1:7.2
5	To design and construct Monostable multivibrators using IC 555.	CO 3	T2:10.4 , R2:7.2
6	To design and construct schimitt trigger using NE555 Timer.	CO 3	T2:10.4 , R1:7.2
7	To verify characteristics of PLL.	CO 4	T2:10.4 , R1:7.2
8	To design and verify the operation of instrumentation amplifier using IC 741.	CO 1	T1:8.2-8.5
9	To verify Functionality of multiplexer and demultiplexer.	CO 6	T1:11.1-11.5
10	To verify Functionality of encoder and decoder.	CO 6	T1:10.1 , T1:10.2
11	To verify Functionality of flip-flop.	CO 6	T1:11.1-11.5
12	To verify Functionality of counters.	CO 6	T3:3.12 , R1:12.7
13	To verify Functionality of shit register.	CO 6	T3:3.12 , R1:12.7
14	To verify Functionality of decade counter.	CO 6	T3:3.12 , R1:12.7

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design an automatic Street Light using 555 timer and LDR.
2	Design an analog Temperature Sensor detector using IC 741.
3	Design an Electronic Eye controlled security system using LDR.
4	Design PWM Based DC Fan Controller using IC 555 timer.
5	Design an automatic Washroom Light Switch using IC741.

Signature of Course Coordinator **HOD, ECE**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**POWER SYSTEM ANALYSIS**				
Course Code	AEE012				
Program	B.Tech				
Semester	VI				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Dr. P. Rajendhar, Associate Professor, EEE				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE005	III	Network Analysis
B.Tech	AEE011	V	Transmission and Distribution Systems

II COURSE OVERVIEW:

Power System Analysis course enables students to study the performance of interconnected power system under steady state and transient stability conditions. The course deals with formation of impedance and admittance matrices for various configurations, finding unknown electrical quantities at various buses, symmetrical and unsymmetrical fault analysis, power system using per unit representation. The course helps in selecting the protective devices to gain back normal operation of power system.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Power System Analysis	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
40%	Understand
50%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination

Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

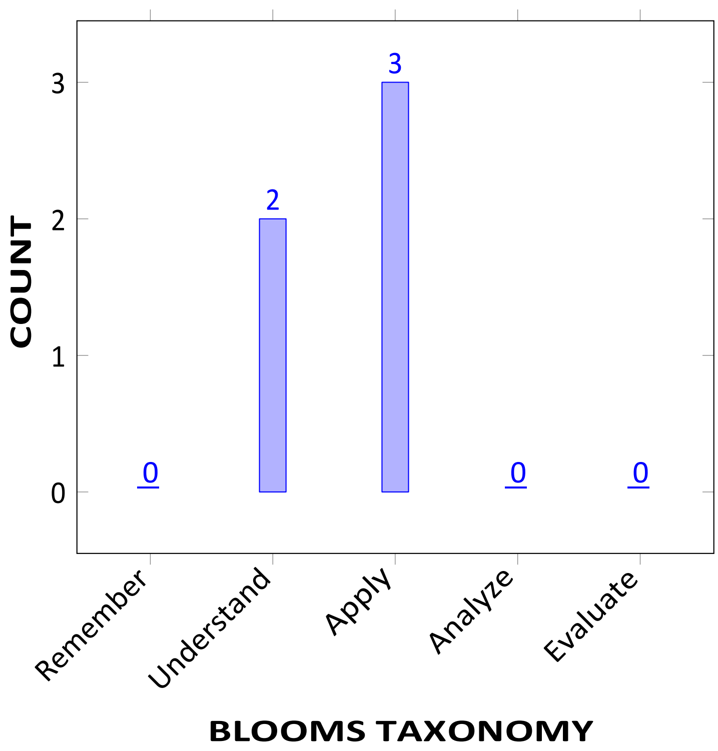
I	The methods to build the bus impedance and bus admittance matrices for primitive and non-primitive networks.
II	The numerical methods for load flow analysis of n bus interconnected power system.
III	The theorems and techniques involved in the fault level calculations during balanced and unbalanced faults.
IV	The performance of power system under steady and transient state stability conditions.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Build** the mathematical models and matrices of interconnected power system network for analyzing power flows and fault conditions	Apply
CO 2	**Develop** a network's power flow problem and solve it using multiple iterative strategies in obtaining optimal solution	Apply
CO 3	**Experiment** with power system fault analysis for balanced and unbalanced faults in order to determine fault levels and protective device ratings, as well as to grasp the ideas of per-unit system.	Apply
CO 4	**Classify** the different types of stability, including the elements that influence the steady state stability limitations and how to improve it	Understand
CO 5	**Demonstrate** the different numerical integration and graphical approaches to understand the transient stability and the factors affecting as well as the methods of enhancing it	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3	CIE/Quiz/AAT
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Analyse Design, investigate, simulate and/or fabricate/commission the electrical system involving generation, transmission, distribution and utilization of electrical energy.	3	Research Paper / Quiz / AAT

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	✓	-	-	-	-	-	-	-	-		✓	-	-
CO 2	✓	-	✓	-	✓	-	-	-	-	-	-		✓	-	-
CO 3	✓	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	-
CO 4	✓	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	-
CO 5	✓	✓	✓	-	✓	-	-	-	-	-	-	-	✓	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Define the nomenclature of graph theory,procedure to form incidence matrices with knowledge of **mathematics, science and engineering fundamentals.** which are useful for load flow and fault analysis	3
	PO 3	Form the bus impedance and admittance matrices **to understand required specifications for load flow analysis of power system.** and to understand the formation of modified bus impedance matrix for various changes in the existing network.	5
	PSO 1	Understand the concepts of graph and matrix theory which helps in **load flow analysis of power system.** and to design the solution a solution with inclusion of line charging capacitance to the power transmission network	2
CO 2	PO 1	Recollect the numerical methods for solving linear and nonlinear algebraic equations those are encountered in power flow studies with knowledge from mathematics and engineering fundamentals **basic fundamentals of science, and engineering fundamentals.**	3
	PO3	**Designing a load flow problem and to develop solutions for the same** using different numerical methods for different conditions of the bus systems	6
	PO 5	Draw the flow chart of numerical methods used to find solution of power flow problem **helps in simulation interconnected system for all requited specifications.**	1
	PSO 1	**Simulate the power system to obtain complete data of the buses** under various set of conditions in analysing power flows of a network	3
CO 3	PO 1	Recollect the definitions of electrical quantities to introduce per unit system and symmetrical component theory using **fundamentals of mathematics, science, and engineering fundamentals.**	3
	PO 2	Understand the different types of faults on any power system and its effects **using basic mathematics and engineering principles.**	7
	PO 3	**Design the ratings for protective devices under complex power system fault conditions and to incorporate fault limiting devices**	5
	PSO 1	**Usage of per unit method and symmetrical components** to understand the symmetrical and unsymmetrical faults which helps in **designing a switch gear equipment of power system.**	3
CO 4	PO 1	Recollect the dynamics of electrical components to analyze and classify the stability of power system with basic **fundamentals of mathematics science and engineering fundamentals.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Determine the conditions and limits for power system using various methods **to meet the stability requirement specifications.**	6
	PO3	Determine solutions to avoid power system stability issues and to give suggestions for enhancing the steady state stability	6
	PSO 1	Understand the **necessity of stability study in power system for economic and reliable operation.**	3
CO 5	PO 1	Recollect the dynamics of electrical components to find the solution for swing equation and understand equal area criterion and point by point method with **basic fundamentals of mathematics science and engineering fundamentals.**	3
	PO2	Understand the concepts of equal area criterion and point by method in analyzing transient stability **of complex power system with basic mathematics and engineering sciences.**	7
	PO 3	**Calculate the critical clearing angle to determine the condition** to underlie in the limits of transient state stability.	6
	PO 5	**Usage of software tools and flow charts** to understand the complex power system problems such as load flows, fault studies and stability in an simulation environment	1
	PSO1	Understand the importance of load flow studies, fault analysis and stability **in planning, operation and requirements of power system**	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	5	-	-	-	-	-	-	-	-		2	-	-
CO 2	3	-	6	-	1	-	-	-	-	-	-		3	-	-
CO 3	3	7	5	-	-	-	-	-	-	-	-	-	3	-	-
CO 4	3	6	6	-	-	-	-	-	-	-	-	-	3	-	-
CO 5	3	7	6	-	1	-	-	-	-	-	-	-	4	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	50	-	-	-	-	-	-	-	-		40	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 2	100	-	60	-	100	-	-	-	-	-	-		60	-	-
CO 3	100	70	50	-	-	-	-	-	-	-	-	-	60	-	-
CO 4	100	60	60	-	-	-	-	-	-	-	-	-	60	-	-
CO 5	100	70	60	-	100	-	-	-	-	-	-	-	80	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -5 $< C \leq 40\%$ – Low/ Slight

2 - 40 % $< C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	2	-	-	-	-	-	-	-	-	-	2	-	
CO 2	3	-	3	-	3	-	-	-	-	-	-	-	3	-	-
CO 3	3	3	2	-	-	-	-	-	-	-	-	-	3	-	-
CO 4	3	3	3	-	-	-	-	-	-	-	-	-	3	-	-
CO 5	3	3	3	-	3	-	-	-	-	-	-	-	3	-	-
TOTAL	30	18	23	-	6	-	-	-	-	-	-	-	29	-	-
AVERAGE	3.0	3.0	3.0	-	3.0	-	-	-	-	-	-	-	3.0	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	PO 1,PO 2, PO 3, PO 5	SEE Exams	PO 1,PO 2, PO 3, PO 5	Seminars	PO 1,PO 2, PO 3, PO 5
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 1,PO 2, PO 3, PO 5	Open Ended Experiments	-
Assignments	PO 1,PO 2, PO 3, PO5				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

X	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**POWER SYSTEM NETWORK MATRICES**
	Graph Theory: Definitions, bus incidence matrix, Y bus formation by direct and singular transformation methods, numerical problems; Formation of Z Bus: Partial network, algorithm for the modification of Z bus matrix for addition of element from a new bus to reference bus, addition of element from a new bus to an old bus, addition of element between an old bus to reference bus and addition of element between two old busses (Derivations and Numerical Problems), modification of Z bus for the changes in network (Numerical Problems).
MODULE II	**POWER FLOW STUDIES AND LOAD FLOWS**
	Load flows studies: Necessity of power flow studies, data for power flow studies, derivation of static load flow equations; Load flow solutions using Gauss Seidel method: Acceleration factor, load flow solution with and without PV buses, algorithm and flowchart; Numerical load flow solution for simple power systems (Max. 3 buses): Determination of bus voltages, injected active and reactive powers (Sample one iteration only) and finding line flows / losses for the given bus voltages; Newton Raphson method in rectangular and polar coordinates form: Load flow solution with or without PV busses derivation of Jacobian elements, algorithm and flowchart, decoupled and fast decoupled methods, comparison of different methods, DC load flow study.
MODULE III	**SHORT CIRCUIT ANALYSIS PER UNIT SYSTEM OF REPRESENTATION**
	Per unit system: Equivalent reactance network of a three phase power system, numerical problems; Symmetrical fault analysis: Short circuit current and MVA calculations, fault levels, application of series reactors, numerical problems; Symmetrical component theory: Symmetrical component transformation, positive, negative and zero sequence components, voltages, currents and impedances. Sequence networks: Positive, negative and zero sequence networks, numerical problems; Unsymmetrical fault analysis: LG, LL, LLG faults with and without fault impedance, numerical problems.
MODULE IV	**STEADY STATE STABILITY ANALYSIS**
	Steady state stability: Elementary concepts of steady state, dynamic and transient stabilities, description of steady state stability power limit, transfer reactance, synchronizing power coefficient, power angle curve and determination of steady state stability and methods to improve steady state stability.
MODULE V	**TRANSIENT STATE STABILITY ANALYSIS**
	Swing equation: Derivation of swing equation, determination of transient stability by equal area criterion, application of equal area criterion, critical clearing angle calculation, solution of swing equation, point by point method, methods to improve stability, application of auto reclosing and fast operating circuit breakers.

TEXTBOOKS

1. D P Kothari and I J Nagrath, "Power System Engineering", McGraw-Hill Education, 2nd Edition, 2007.
2. M A Pai, "Computer Techniques in Power System Analysis", TMH Publications, 2nd edition, 2005.
3. B R Guptha, "Power system analysis and Design" S. Chand Publishing, 2nd edition,

1998.

4. K Umarao, "Computer techniques and models in power systems", I K International Pvt. Ltd., 2nd edition, 2006.

REFERENCE BOOKS:

1. Stagg , El Abiad, " Computer Methods In Power System". Tata McGraw-Hill.1968.
2. Grainger and Stevenson, "Power System Analysis", Tata McGraw-Hill, 3rd Edition, 2011.
3. J Duncan Glover and M S Sarma., THOMPSON, "Power System Analysis and Design", 3rd Edition 2006.
4. Abhijit Chakrabarthi and Sunita Haldar, "Power system Analysis Operation and control", 3rd Edition, PHI, 2010.

WEB REFERENCES:

1. https://nptel.ac.in/courses/108/105/108105067/

COURSE WEB PAGE:

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1			
CONTENT DELIVERY (THEORY)			
1	Introduction to graph theory.	CO 1	T4:9.41, R1:3.1-3.2
2	Solve numerical problems on graph theory.	CO 1	T4:9.4.1, R1:3.1-3.2
3	Building bus incidence matrix.	CO 1	T4:9.4.3, R1:3.3-3.5
4	Forming Y bus formation by direct method.	CO 1	T4:9.2, R1:3.3-3.5
5,6	Forming Y bus formation by singular transformation. methods,	CO 1	T4:9.2, R1:3.3-3.5
7	Solve numerical problems on bus matrices.	CO 1	T4:9.2, R1:3.3-3.5
8	Formation of ZBUS: Partial network.	CO 1	T4:9.4, R1:4.1

9	Algorithm for the Modification of Z Bus Matrix for addition element from a new bus to reference.	CO 1	T4:9.3-9.5, R1:4.2
10	Algorithm for the Modification of Z Bus Matrix for addition element from a new bus to an old bus.	CO 1	T4: 9.3-9.5, R1:4.3-4.4
11,12	Algorithm for the Modification of Z Bus Matrix for addition element between an old bus to reference Addition of element between two old busses (Derivations and Numerical Problems without mutual coupling).	CO 1	T4: 9.3-9.5, R1:4.3-4.4
13	Study of necessity of power flow studies – Data for power flow studies – derivation of static load flow equations.	CO 2	T4:9.1, R1:8.1
14	Solution of load flow solutions using Gauss Seidel Method: Acceleration Factor.	CO 2	T4:9.8, R1:8.2
15	Load flow solution with and without P- V buses, Algorithm and Flowchart.	CO 2	T4:9.9.1, R1:9.2
16,17	Find numerical load flow solution for simple power systems (Max. 3- Buses): Determination of bus voltages, injected active and reactive powers (Sample One Iteration only).	CO 2	T4:9.8, R1:9.2
18,19	Discuss on newton raphson method in rectangular form: load flow, solution with or without PV busses- Derivation of jacobian elements.	CO 2	T4:9.10, R1:9.2
20	Discussion newton raphson method in polar co- ordinates form: load flow solution with or without pv busses-Derivation of jacobian elements.	CO 2	T4:9.11.2, R1:9.2
21,22	Study on decoupled and fast decoupled methods for load flow solution.	CO 2	T4:9.12, R1:9.2
23	Comparison of Different Methods – DC load Flow.	CO 2	T4:9.4.12, R1:9.2
24,25	Short Circuit Analysis: Short Circuit Current and MVA Calculations.	CO 3	T4:10.3, R1:6.1-6.3
26	Understand fault levels.	CO 3	T4:10.4, R1:6.1-6.3
27	Application of series reactors.	CO 3	T4:10.4, R1:6.1-6.3
28	Solving numerical problems (Symmetrical fault Analysis).	CO 3	T4:10.4, R1:6.4
29	Understand symmetrical component transformation, positive, negative and zero sequence components.	CO 3	T4:10.5, R1:6.4
30	Draw sequence networks.	CO 3	T4:10.6, R1:6.3
31	Derive sequence voltages, currents and impedances.	CO 3	T4:10.7, R1:6.3
32	Solving numerical problems on symmetrical components.	CO 3	T4:10.5, R1:6.3

33,34	Understand LG fault with and without fault impedance and numerical problems.	CO 3	T4:10.13, R1:6.3
35,36	Study fault with and without fault impedance and numerical problems.	CO 3	T4:10.13, R1:6.1-6.3
37,38	Determine LLG fault with and without fault impedance and numerical problems.	CO 3	T4:10.16, R1:6.1-6.3
39	Compare LG, LL, LLG faults with and without fault impedance and numerical problems.	CO 3	T4:10.17, R1:6.1-6.3
40,41	Introduction to steady state, dynamic and transient stabilities.	CO 4	T4:13.1, R1:10.1
42,44	Description of steady state stability power limit, transfer reactance, synchronizing power coefficient.	CO 4	T4:13.2, R1:10.3
45,46	Plot Power Angle Curve and determination of steady state,. stability.	CO 4	T4:13.2, R1:6.4
47,48	Explain methods to improve steady state stability.	CO 4	T4:13.2, R1:10.3
49	Derivation of swing equation.	CO 4	T4:13.3, R1:10.2
50,51	Determination of transient stability by equal area criterion.	CO4	T4:13.6, R1:10.5
52	Application of equal area criterion to different cases.	CO 4	T4:13.7, R1:10.5
53	Discuss importance of critical clearing angle calculation.	CO 4	T4:13.6, R1:10.5
54,55	Solving numerical problems on equal area criteria.	CO 4	T4:13.7, R1:10.5
56	Solution of swing equation: point-by- point method.	CO 4	T4:13.8, R1:10.5
57	Explain methods to improve stability.	CO 5	T4:13.11, R1:10.6
58	Application of auto reclosing and fast operating circuit breakers.	CO 5	T4:13.11, R1:10.7
PROBLEM SOLVING/ CASE STUDIES			
1	15 problem solving classes	CO 1	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	5 classes	CO 1	R4:2.1
DISCUSSION OF QUESTION BANK			
1	Module I	CO 1	R4:2.1
2	Module II	CO 2	T4:7.3
3	Module III	CO 3	R4:5.1
4	Module IV	CO 4	T1:7.5
5	Module V	CO 5	T1: 4.1

Signature of Course Coordinator **HOD,EEE**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**SOLID STATE ELECTRIC MOTOR DRIVES**				
Course Code	AEE013				
Program	B.Tech				
Semester	VI				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	P SHIVAKUMAR Asistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE015	IV	Electrical Machines - II
B.Tech	AEE020	V	Power Electronics

II COURSE OVERVIEW:

This course deals with the basic theory, construction, operation, performance characteristics and application of electromechanical energy conversion devices such as synchronous and asynchronous machines. It also facilitates the study of the alternating machines which are the major part of industrial drives and agricultural pump sets

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electrical drives and static control	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with ”either” or ”choice” will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
83.33 %	Understand
16.66%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

VI COURSE OBJECTIVES:

The students will try to learn:

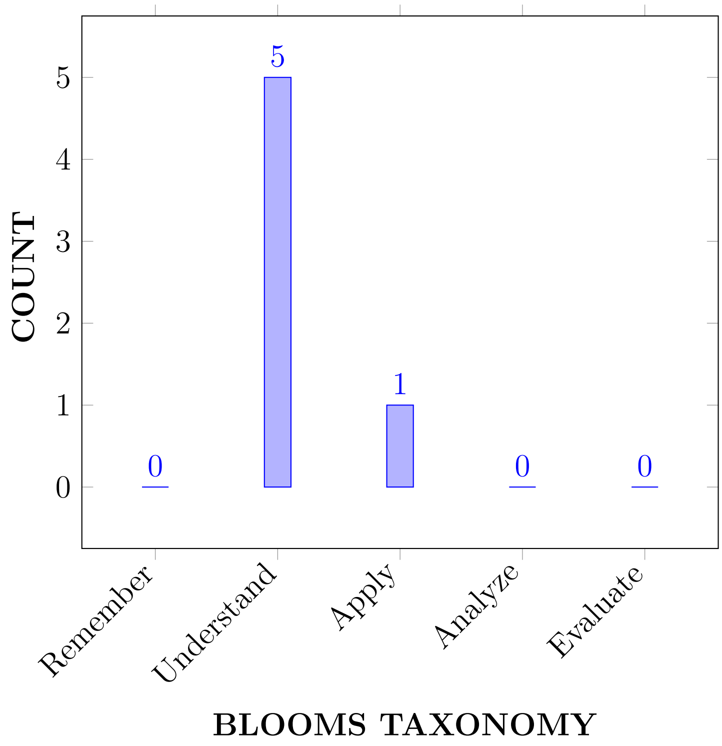
I	The steady state behavior and transient dynamics of the converter/chopper fed DC drive.
II	The steady state behavior and transient dynamics of the converter/chopper fed DC drive
III	The performance of different industrial drives considering issues such as energy efficiency, power quality, economic justification, environmental issues and practical liabilities.
IV	Starting, braking, and speed control arrangements for electric motors and their applications.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Illustrate** the speed control of DC motors with single phase and three phase-controlled rectifiers for verification of speed torque characteristics	Understand
CO 2	**Explain** the four-quadrant chopper fed dc motor drives for verification of speed torque characteristics	Understand
CO 3	**Describe** the working of stator voltage control of induction motor for speed control of the drive.	Understand
CO 4	**Identify** the variable frequency control methods for induction motor drive applications.	Apply
CO 5	**Summarize** the slip power recovery schemes, direct and indirect vector control methods for speed control of induction motors.	Understand
CO 6	**Demonstrate** the working of voltage source and current source inverter fed synchronous motor dive for speed control applications.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/CIE/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	SEE/CIE/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	SEE/CIE/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development	2	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-		-	✓	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-
CO 4	✓	✓	-	-		-	-	-	-	-	-		-	✓	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	-	-		-	-	-	-	-	-	-	-	✓	

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall the speed control of DC motors with single phase and three phase-controlled rectifiers using science and engineering fundamentals.	3
	PO 2	Understand speed torque characteristics of dc motor using first principles of mathematics and engineering sciences	6
	PSO 2	Demonstrate the speed control of dc drives using rectifiers topologies for energy conversion and specific applications of industry	7
CO 2	PO 1	Demonstrate the fourquadrant chopper fed dc motor using science and engineering fundamentals	2
	PO 2	Illustrate thechopper controlled drives using first principles of mathematics and engineering sciences.	6
	PO 4	Demonstrate the speed torque characteristics of chopper fed drives	6
	PSO 2	Demonstrate the speed control of dc drives using rectifiers topologies for energy conversion and specific applications of industry	6
CO 3	PO 1	Understand stator voltage control of induction motor using engineering fundamentals	3
	PO 2	Illustrate speed control of induction motor drives using first principles of mathematics and engineering sciences	6
	PSO 2	Demonstrate stator voltage control of induction motor drive using AC voltage controller for energy conversion and specific controller applctions of industry needs	7
CO 4	PO 1	Understand v/f control of induction motor drive using engineering funda	3
	PO 2	Demonstrate v/f control of ac using first principles of mathematics and engineering sciences	7
	PSO 2	Illustrate operation of AC drives with v and f using different control topologies for energy conversion andspecific applications of induction motor	6
CO 5	PO 1	Understand slip power recovery schemes and vectror controlled drives using knowledge of science and engineering fundamentals	3
	PO 2	Understand understand slip power recovery schemes and vectror controlled of induction motor with knowledge of science and engineering fundamentals	7
	PSO 2	Demonstrate speed control of induction motor with static rotor resistance controlling different control topologies for energy conversion andspecific applications of induction motol	6

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	PO 1	Voltage source inverter and current source inverter fed drives with knowledge of science and engineering fundamentals	3
	PO 2	Describe the control of synchronous motor drive using science and engineering fundamentals	6
	PO 4	Develop self and separately control of ac drives with analysis and innterpretition of data	6
	PSO 2	Illustrate synchronous motor drives with converter topologies voltage and current source inverter	7

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	6	-	-	-	-	-	-	-	-	-		-	7	-
CO 2	2	6	-	6	-	-	-	-	-	-	-	-	-	6	-
CO 3	3	6	-	-	-	-	-	-	-	-	-	-	-	7	-
CO 4	3	7	-	-		-	-	-	-	-	-		-	6	-
CO 5	3	6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	5	-	6	-	-	-	-	-	-	-		-	7	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	60	-	-	-	-	-	-	-	-	-		-	63.6	-
CO 2	66	60	-	60	-	-	-	-	-	-	-	-	-	54.5	-
CO 3	100	70	-	-	-	-	-	-	-	-	-	-	-	63.6	-
CO 4	100	70	-	-		-	-	-	-	-	-		-	63.6	-
CO 5	100	70	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	60	-	60		-	-	-	-	-	-		-	63.6	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 -5 $< C \leq 40\%$ – Low/ Slight
2 - 40 % $< C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	-	-	-	-	3	
CO 2	2	2	-	2	-	-	-	-	-	-	-	-	-	2	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 4	3	3	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 5	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	2	-	-	-	-	-	-	-	-	-	3	-
TOTAL	17	14	2	-	4	-	-	-	-	-	-	-	3	11	6
AVERAGE	2.8	2.33	-	2	-	-	-	-	-	-	-	-	3	2.2	3

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	-
Quiz	-	Tech - Talk	✓	Certification	-
Term Paper	-	Seminars	-	Student Viva	-
Laboratory Practices		5 Minutes Video / Concept Video	✓	Open Ended Experiments	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
x	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts	-	-

XVIII SYLLABUS:

MODULE I	**CONTROL OF DC MOTORS THROUGH PHASE CONTROLLED RECTIFIERS**
	Introduction to thyristor controlled drives: Single phase semi and fully controlled converters connected to DC separately excited and dc series motors, continuous current operation, output voltage and current waveforms, speed and torque expressions, speed torque characteristics, problems on converter fed DC motors; Three phase semi and fully controlled converters connected to DC separately excited and DC series motors, output voltage and current waveforms, speed and torque expressions, speed torque characteristics and problems.

MODULE II	**SPEED CONTROL OF DC MOTORS**
	Introduction to four quadrant operation: Motoring operations, electric braking, plugging, dynamic and regenerative braking operations; Four quadrant operation of DC motors by dual converters, closed loop operation of DC motor; Chopper fed DC drives: Single quadrant, two quadrant and four quadrant chopper fed DC separately excited and series excited motors, continuous current operation output voltage and current wave forms, speed torque expressions, speed torque characteristics, problems on chopper fed DC motors and closed loop operation.
MODULE III	**SPEED CONTROL OF INDUCTION MOTORS THROUGH VARIABLE VOLTAGE AND FREQUENCY**
	Variable voltage characteristics: Control of induction motor by AC voltage controllers, waveforms, speed torque characteristics. Variable frequency characteristics: Variable frequency characteristics, variable frequency control of induction motor by voltage source and current source inverter and cycloconverters, pulse with modulation control, comparison of voltage source inverter and current source inverter operations, speed torque characteristics, numerical problems on induction motor drives, closed loop operation of induction motor drives.
MODULE IV	**SPEED CONTROL OF INDUCTION MOTORS THROUGH ROTOR RESISTANCE AND VECTOR CONTROL**
	Static rotor Resistance control: Slip power recovery schemes, static Scherbius drive, static Kramer drive, their performance and speed torque characteristics, advantages and applications, vector control of induction motor drives: Principles of vector control, vector control methods, direct methods of vector control, indirect methods of vector control and problems.
MODULE V	**SPEED CONTROL OF SYNCHRONOUS MOTORS**
	Separate control and self-control of synchronous motors, operation of self-controlled synchronous motors by voltage source inverter and current source inverter cyclo converters. Load commutated CSI fed synchronous motor, operation, waveforms, speed torque characteristics, applications, advantages and numerical problems, closed loop control operation of synchronous motor drives (block diagram only), variable frequency control, cycloconverter, PWM, variable frequency inverter and current source inverter.

TEXTBOOKS

1. PV Rao, "Power Semiconductor Drives", BS Publications, 1st Edition, 2014.

2. G K Dubey, "Fundamentals of Electric Drives", Narosa Publications, 2nd Edition, 2001.

REFERENCE BOOKS:

1. Vedam Subramanyam, "Thyristor Control of Electric Drives", Tata McGraw Hill Publication, 5th Edition, 2008.

2. John Hindmarsh, Alasdair Renfew", Electrical machines and drive systems", Oxford Butterworth Heinemann, 3rd Edition.

3. Austin Hughes, "Electrical motors and drives Fundamentals Types and Applications", Elsevier, 3rd Edition, 2006.

WEB REFERENCES:

1. https://www.electrical4u.com

2. https://www.freevideolectures.com

COURSE WEB PAGE:

1. https://lms.ac.in

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Presentation on Outcome based education		
CONTENT DELIVERY (THEORY)			
2	Understand the principle of thyristor controlled drives	CO1	T2:2.3,
3	Describe the operation of Single phase semi controlled converters connected to DC separately excited motors	CO1	T1: 5.2
4	Understand the operation Single phase semi controlled converters connected to DC series motors	CO1	T2:2.2 R2:1.1-1.8
5	Analyze the problems on Single phase semi controlled converters fed DC motors	CO1	T1: 5.6 R2:2.3
6	Discuss the operation of Single phase fully controlled converters connected to DC separately excited motors	CO1	T1: 5.7 R2:2.3
7	Describe the operation of Single phase fully controlled converters connected to DC series motors	CO1	T1: 5.7.1 R2:3.2
8	Analyze the problems on Single phase fully controlled converters fed DC motors	CO1	T1:5.8 R2:3.2
9	Demonstrate the operation of Three phase semi controlled converters connected to DC separately excited motors	CO1	T2:6.6 R2:2.9
10	Understand the operation of Three phase semi controlled converters connected to DC series motors	CO1	T2:5.7 R2:2.9
11	Analyze the problems on three phase semi controlled converters fed DC motors	CO1	T1:6.1 R2:2.9-2.10
12	Describe the operation of Three phase fully controlled converters connected to DC separately excited motors	CO1	T1:6.2 R2:2.11
13	Discuss the operation of Three phase fully controlled converters connected to DC series motors	CO1	T1:6.2 R2:2.11
14	Analyze the problems on three phase fully controlled converters fed DC motorsn	CO1	T1:6.3 R2:3.5
15	Understand the four quadrant operation of DC motors	CO2	T1:6.1.2 R2:3.5
16	Describe the electric braking operations	CO2	T1:6.1.2 R2:3.7
17	Demonstrate the Regenerative braking operations of DC Motors	CO2	T1:13.1 R2:3.7
18	Discuss the Four quadrant operation of DC motors by dual Converters	CO2	T1:13.2 R2:3.7
19	Describe the closed loop operation of DC motor with four quadrant operations	CO2	T1:13.2 R2:3.7

20	Understand the operation of Single quadrant chopper fed DC separately excited and series motors	CO2	T1:8.2 R2:3.7
21	Describe the operation of Two quadrant chopper fed DC separately excited and series motors	CO2	T1:11.3 R2:2.11
22	Analyze the problems on Chopper fed DC motors	CO2	T2:4.5 R2:4.1
23	Discuss the operation of Four quadrant chopper fed DC separately excited and series motors	CO2	T2:4.6 R2:5.1
24	Analyze the problems on Chopper fed DC motors.	CO2	T2:4.7 R2:5.2
25	Demonstrate the Closed loop operation of chopper fed DC motors	CO2	T1:11.2 R2:5.4
26	Understand the variable voltage characteristics of induction Motor	CO5	T2:4.6 R2:4.3-4.4
27	Discuss the speed control of induction motor by AC voltage Controllers	CO3	T2:4.6.2 R2:4.3-4.4
28	Describe the Speed torque characteristics of induction motor with variable voltage	CO3	T2:4.6.3 R2:4.5
29	Demonstrate the variable frequency characteristics of induction motor	CO4	T1:12.3 R2:5.2
30	Understand the operation of voltage source inverter fed induction motor	CO4	T1:12.3 R2:6.1
31	Discuss the operation of current source inverter fed induction Motor	CO3	T1:12.1 R2:6.2
32	Describe the operation of cycloconverter fed induction motor	CO4	T111.4: R2:7.1-7.2
33	Apply the pulse width modulation control for variable frequency control of induction motor	CO4	T2:3.3 R2:7.4
34	Distinguish voltage source inverter and current source inverter	CO4	T2:3.1 R2:7.4
35	Analyze the numerical problems on induction motor drives	CO4	T1:13.2 R2:7.4
36	Demonstrate the Closed loop operation of induction motor drives	CO3	T1:13.3 R2:7.4
37	Analyze the numerical problems on induction motor drives	CO4	T1:12.1, R2:7.3
38	Understand the operation of rotor resistance control of induction motors	CO5	T1:12.4 R2:7.3
39	Discuss the Static rotor Resistance control of induction motors	CO5	T1:12.4 R2:7.4
40	Demonstrate the Slip power recovery schemes of induction motor	CO5	T2:7.1
41	Describe the operation of static Scherbius drive	CO5	T1:12.4.1
42	Understand the operation of static Kramer drive	CO5	T2:12.4.2 R2:7.4

43	List the advantages and applications of slip power recovery Schemes	CO5	T2:7.2 R2:6.3
44	Understand the principles of vector control of induction motor	CO5	T1:12.4.3 R2:7.8
45	Describe the vector control methods of induction motor	CO5	T1:12.4.4 R2:7.8
46	Demonstrate the direct methods of vector control	CO5	T2:7.1 R2:6.3
47	Understand the Separate control of synchronous motors	CO6	T2:7.1 R2:6.3
48	Describe the Self control of synchronous motors	CO6	T2:7.1 R2:6.3
49	Describe the operation of Load commutated CSI fed synchronous motor	CO6	T2:7.1 R2:6.3
50	Describe the operation of Load commutated CSI fed synchronous motor	CO6	T2:7.1 R2:6.3
51	Demonstrate the closed loop control operation of synchronous motor drives with block diagram	CO6	T2:7.1 R2:6.3
52	Describe the Variable frequency inverter and current source inverter fed synchronous motor	CO6	T2:7.1 R2:6.3
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Electric drive,Power Modulator and critical speed	CO1	T1: 5.2 -5.9
2	Dynamic braking,plugging in DC motor and Define chopper	CO2	T1:6.1-6.6
3	soft start, slip, base speed	CO3	T1:8.1-8.6
4	VSI and CSI plugging in induction motor drives	CO4,CO5	T1:12.1-12.8
5	self control,separate control and power factor control	CO6	T1:13.1-13.9
DISCUSSION OF QUESTION BANK			
1	Control of dc motors through phase controlled rectifiers	CO1	T2: 3.2-3.3
2	Speed control of dc motors	CO2	T3: 6.9-6.14
3	Speed control of induction motors through variable voltage and frequency	CO3,4	T2: 5.1-5.20
4	Speed control of induction motors through rotor resistance and vector control	CO5	T2: 7.1-7.20
5	Speed control of synchronous motors	CO6	T3:36.8

Course Coordinator **HOD,EEE**
Mr P.Shivakumar , Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electronics and Communication Engineering**				
Course Title	**Microprocessors and Microcontrollers**				
Course Code	AEC013				
Program	B.Tech				
Semester	VI				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Ms B. Lakshmi Prasanna, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEC002	III	Digital System Design
B.Tech	AEC010	V	Computer organization

II COURSE OVERVIEW:

Processor and Controller cores are the key components in most of the modern embedded and system-on-chip designs. This course outlines the architecture and signal description of Intel microprocessor and microcontrollers. The instruction set and assembly language programming along with I/O and memory interfacing techniques are covered. The knowledge acquired from this course will enable the students in development of embedded hardware projects and models for engineering and scientific applications.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Microprocessors and Microcontrollers	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with ”either” or ”choice” will be drawn from each module. Each question carries 14 marks. There could

be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
50 %	Understand
30 %	Apply
10 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

VI COURSE OBJECTIVES:

The students will try to learn:

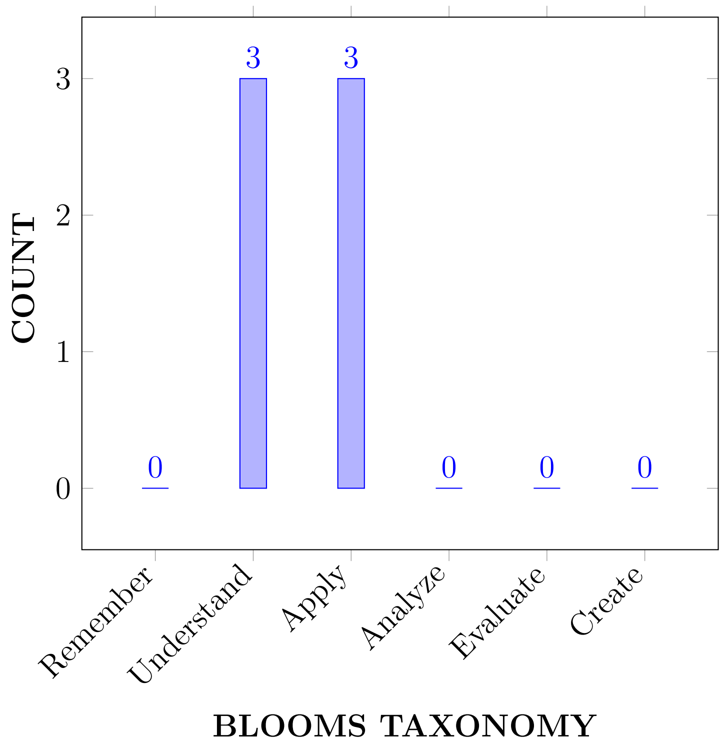
I	The signal descriptions along with functional architecture and hardware interfacing skills using microprocessors and microcontrollers.
II	The instruction set and logic to build assembly language programs for arithmetic, logic and automated electronic systems.
III	The essential concepts of development through a practical hands-on approach on advanced ARM processors and Internet of Things based systems.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Outline** the functional components of microprocessors and microcontrollers for understanding the operation of architectures.	Understand
CO 2	**Make use of** addressing modes and instruction set of target microprocessors and microcontrollers for writing an assembly language programs to perform a task.	Apply
CO 3	**Demonstrate** the internal architecture and modes of operation of peripheral devices for interfacing memory and I/O devices.	Understand
CO 4	**Illustrate** the interrupt handling mechanism in microprocessors and microcontrollers using interrupt controller.	Understand
CO 5	**Choose** an appropriate data transfer scheme and hardware for data transfer between the devices.	Apply
CO 6	**Develop** microprocessor and microcontroller based applications using necessary input and output devices.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations

Program Outcomes	
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE, CIE, AAT , QUIZ
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	SEE, CIE, AAT, QUIZ
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	SEE, CIE, AAT , QUIZ

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 10	**Communication:** Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	SEE, CIE, AAT , QUIZ

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Build embedded software and digital circuit development platform for robotics, embedded systems and signal processing applications.	3	AAT

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	✓	-	-	-	-	-	-	-	-	✓	-		-	-	-
CO 2	✓	✓	✓	-	-	-	-	-	-	✓	-	-	✓	-	-
CO 3	✓	✓	✓	-	-	-	-	-	-	✓	-	-	-	-	-
CO 4	-	✓	✓	-	-	-	-	-	-	✓	-	-	-	-	-
CO 5	-	✓	✓	-	-	-	-	-	-	✓	-	-	-	-	-
CO 6	✓	✓	✓	-	-	-	-	-	-	✓	-	-	✓	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Describe the features and architectures of Intel 8086 processor and Intel 8051 microcontroller (knowledge) by applying the knowledge of **mathematics, Engineering fundamentals,** and electronics **engineering specialization** for understanding the operation.	3
	PO 10	Explain the functional components of microprocessors and microcontrollers by **giving effective presentations and receive clear instructions** for understanding the operation of architectures.	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO 1	Illustrate instructions from the set library (knowledge) for efficient assembly level programming by applying the knowledge of **science, engineering fundamentals and mathematics.**	3
	PO 2	Select proper instructions from the instruction set by **Information and data collection** for **Solution development** by writing assembly language level programming efficient and **Interpretation of results**	3
	PO 3	**Manage the design process** and make use of **creativity to establish solutions** by selecting proper mnemonics to write the assembly language level programming by **Understanding of the requirement for engineering activities to promote sustainable development.**	3
	PO 10	Utilize addressing modes and instruction set of target microprocessors and microcontrollers microcontrollers by **giving effective presentations and receive clear instructions** for writing an assembly language programs to perform a task .	1
	PSO 1	Develop software program skills to write efficient programs by **understanding the performance parameters** of software/ Hardware systems for **robotics, embedded systems and signal processing applications**	2
CO 3	PO 1	Illustrate the internal architecture and modes of operation of peripheral devices like PPI, DMA controller, PIC, USART by applying the principles of **mathematics, engineering fundamentals, electronics engineering specialization** for the solution of complex engineering problems.	3
	PO 2	Explain the **Problem statement and system definition** for interfacing devices with microprocessor and microcontroller by **Information and data collection** using peripheral devices like PPI, DMA controller, PIC, USART for **Solution development** and **Interpret the results**	4
	PO 3	**Manage the design process and evaluate outcomes** by interfacing devices with microprocessor and microcontroller using Programmable Peripheral Interface (PPI) and Interrupt Controllers **to establish innovative solutions** by**Understanding of the requirement for engineering activities to promote sustainable development**	3
	PO 10	Describe the internal architecture and modes of operation of peripheral devices by **giving effective presentations and receive clear instructions** for interfacing memory and I/O devices.	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 4	PO 2	Explain the functionality of various types of interrupts and their structure with **Information and data collection** for controlling the processor or controller with program execution flow and**Interpret the results** for **solution development** using interrupt controller.	3
	PO 3	**Understand the requirement for engineering activities to promote sustainable development** in Interrupt handling and **use creativity to establish innovative solutions** using interrupt controller by **Managing the design process and evaluate outcomes**	3
	PO 10	Explain the interrupt handling mechanism in microprocessors and microcontrollers by **giving effective presentations and receive clear instructions** using interrupt controller.	1
CO 5	PO 2	Formulate and analyze (Problem analysis) **complex Engineering problems** by differentiating synchronous & asynchronous communication with **Information and data collection** for data transfer between the devices using first principles of **mathematics and Engineering sciences** and then **Interpret the results**	4
	PO 3	**understand the customer and user needs** and select an appropriate data transfer scheme and hardware by **Managing the design process and evaluate outcomes** to **promote sustainable development** for data transfer between the devices **using creativity to establish innovative solutions**	4
	PO 10	Select an appropriate data transfer scheme and hardware by **giving effective presentations and receive clear instructions** for data transfer between the devices.	1
CO 6	PO 1	Build (Apply)necessary hardware and software interface using microcomputer based systems to provide solution for real world problems by applying **knowledge of mathematics, engineering fundamentals, engineering specialization.**	3
	PO 2	**Identify problem** and Choose necessary hardware and software interface **(information and data collection)** and conduct **experimental design** with **model translation** to provide **solution development** for real world problems **by interpreting results.**	6

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 3	Organize necessary hardware and software interface **based on user needs and importance of considerations** for **innovative solutions, of the problem including all aspects to manage design process** , in microcomputer based systems **by applying different techniques, to achieve required sustained development, with legal requirements governing engineering activities, including personnel, health, safety, and risk issues.**	6
	PO 10	Build microprocessor and microcontroller based applications using necessary input and output devices and **give effective presentations and receive clear instructions.**	1
	PSO 1	Develop microprocessor and microcontroller based applications in the fields of r**obotics and embedded systems** using **embedded software** and necessary input output devices.	2

Note: For Key Attributes refer **Annexure - I**

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	3	-	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 2	3	3	3	-	-	-	-	-	-	1		-	2	-	-
CO 3	3	4	3	-	-	-	-	-	-	1	-	-	-	-	-
CO 4	-	3	3	-	-	-	-	-	-	1	-	-	-	-	-
CO 5	-	4	4	-	-	-	-	-	-	1	-	-	-	-	-
CO 6	3	6	6	-	-	-	-	-	-	1	-	-	2	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	100	-	-	-	-	-	-	-	-	20	-	-	-	-	-
CO 2	100	30	30	-	-	-	-	-	-	20	-	-	100	-	-
CO 3	100	40	30	-	-	-	-	-	-	20	-	-	-	-	-
CO 4	-	30	30	-	-	-	-	-	-	20	-	-	-	-	-
CO 5	-	40	40	-	-	-	-	-	-	20	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 6	100	60	60	-	-	-	-	-	-	20	-	-	100	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - $0 \leq C \leq 5\%$ – No correlation
1 -5 $< C \leq 40\%$ – Low/ Slight
2 - 40 % $< C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 2	3	1	1	-	-	-	-	-	-	1	-	-	3	-	-
CO 3	3	2	1	-	-	-	-	-	-	1	-	-	-	-	-
CO 4	-	1	1	-	-	-	-	-	-	1	-	-	-	-	-
CO 5	-	2	2	-	-	-	-	-	-	1	-	-	-	-	-
CO 6	3	3	3	-	-	-	-	-	-	1	-	-	3	-	-
TOTAL	**12**	**9**	**8**	-	-	-	-	-	-	6	-	-	**6**	-	-
AVERAGE	**3**	**1.8**	**1.6**	-	-	-	-	-	-	1	-	-	**3**	-	-

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Quiz	✓	Tech - Talk	-	Certification	-
Term Paper	-	Seminars	-	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	-	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts		

XVIII SYLLABUS:

MODULE I	**8086 MICROPROCESSORS**
	Register organization of 8086, Architecture, signal description of 8086, physical memory organization, general bus operation, I/O addressing capability, special purpose activities Minimum mode, maximum mode of 8086 system and timings, machine language instruction formats, addressing mode of 8086, instruction set of 8086, assembler directives and operators.
MODULE II	**PROGRAMMING WITH 8086 MICROPROCESSOR**
	Machine level programs, programming with an assembler, Assembly language programs, introduction to stack, stack structure of 8086/8088, interrupts and interrupt service routines. Interrupt cycle of 8086, non-mask able interrupt and mask able interrupts, interrupt programming.
MODULE III	**INTERFACING WITH 8086/88**
	Semiconductor memory interfacing, dynamic RAM interfacing, interfacing i/o ports, PIO 8255 modes of operation of 8255,interfacing to D/A and A/D converters, stepper motor interfacing, control of high power devices using 8255. Programmable interrupt controller 8259A, the keyboard /display controller8279, programmable communication interface 8251 USART, DMA Controller 8257.
MODULE IV	**8051 MICROCONTROLLER**
	8051 Microcontroller – Internal architecture and pin configuration, 8051 addressing modes, instruction set, Bit addressable features. I/O Port structures, assembly language programming using data transfer, arithmetic, logical and branch instructions.
MODULE V	**SYSTEM DESIGN USING MICROCONTROLLER**
	8051 Timers/Counters, Serial data communication and its programming, 8051 interrupts, Interrupt vector table, Interrupt programming. Real world interfacing of 8051 with external memory, expansion of I/O ports, LCD, ADC, DAC, stepper motor interfacing.

TEXTBOOKS

1. A.K Ray, K. M. Bhurchandani, "Advanced Microprocessors and Peripherals" Tata McGraw-Hill Education, 2nd Edition, 2012.
2. Muhammad Ali Mazidi, J.G. Mazidi, R.D McKinlay,‖ The 8051 Microcontroller and Embedded systems using Assembly and C‖, Pearson education, 2 nd Edition, 2009.
3. Douglas V. Hall, —Microprocessors and Interfacing Programming and Hardware‖, TMGH, 2 nd Edition, 1994.

REFERENCE BOOKS:

1. Kenneth J. Ayala, —The 8051 Microcontroller‖, Thomson Learning, 3 rd edition, 2005.
2. Manish K. Patel, —The 8051 Microcontroller Based Embedded Systems‖, McGraw Hill, 1st Edition, 2014.
3. Ajay V Deshmukh, ‖Microcontrollers‖, TATA McGraw Hill publications, 2 nd Edition, 2012.

WEB REFERENCES:

1. http://www.nptel.ac.in/downloads/106108100/
2. http://www.the8051microcontroller.com/web-references
3. http://www.iare.ac.in

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=courses/electronics-and-communication-engineering-autonomous/microprocessors-and-microcontrollers

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	https://https://www.iare.ac.in/?q=courses/electronics-and-communication-engineering-autonomous/microprocessors-and-microcontrollers
CONTENT DELIVERY (THEORY)			
2	Register organization of 8086 microprocessor	CO 1	T1:1.1 R2:1.3
3	Flag Register of 8086 Microprocessor	CO 1	T1:1.1 R2:1.2.2
4	Architecture and signal description of 8086 microprocessor	CO 1	T1:1.2 R2:1.1,6.1
5	Physical memory organization of 8086 microprocessor	CO 1	T1:1.4 R2:2.3
7	General bus operation, I/O addressing capability and special purpose activities	CO 1	T1:1.5,1.6,1.7
8	Operation of 8086 microprocessor in minimum mode with read nd write timing diagrams	CO 1	T1:1.8 R2:6.3
9	Operation of 8086 microprocessor in maximum mode with read nd write timing diagrams	CO 1	T1:1.9 R2:6.4
10	Machine language instruction formats	CO 2	T1:2.1 R2:3.1
11	Addressing modes of 8086 Microprocessor	CO 2	T1:2.2 R2:1.4
12	Instruction Set Of 8086 Microprocessor: Data transfer instructions	CO 2	T1:2.3 R2:3.2
13	Instruction Set Of 8086 Microprocessor: Arithmetic and Logical instructions	CO 2	T1: 2.3 R2:3.4,3.5
14	Instruction Set Of 8086 Microprocessor: Program control transfer instructions	CO 2	T1: 2.3 R2:3.3

15	Instruction Set Of 8086 Microprocessor: Machine Control Instructions and Flag manipulation instructions	CO 2	T1: 2.3 R2:3.7
16	Instruction Set Of 8086 Microprocessor: Shift and rotate instructions	CO 2	T1: 2.3 R2:3.6
17	Instruction Set Of 8086 Microprocessor: String instructions	CO 2	T1: 2.3 R2:4.1
18	Assembler Directives and operators	CO 2	T1:2.4 R2:2.2
19	Machine level programs, programming with an assembler	CO 2	T1:3.1,3.2,3.3 R2:2.1
24	Introduction to stack and stack structure of 8086/8088 microprocessor	CO 1	T1:4.1,4.2
25	Interrupts and Interrupt service routines	CO 4	T1:4.3 R2:8.1
26	Interrupt cycle of 8086 microprocessor, non- mask able interrupt and mask able interrupts	CO 4	T1:4.4,4.5,4.6 R2:8.2
27	Interrupt programming	CO 4	T1:4.7
28	Interfacing I/O ports	CO 3	T1:5.3
29	Pin diagram and Architecture 8255 PPI	CO 3	T1:5.4 R2:9.2
30	Operating modes of 8255 PPI	CO 3	T1:5.5 R2:9.3
31	A/D and D/A converters	CO 6	T1:5.6,5.7 R2:9.8,9.9
33	Stepper motor interfacing	CO 6	T1:5.8 R2:9.11
34	Control of high power devices using 8255 PPI	CO 6	T1:5.9
35	Pin configuration of 8259 PIC	CO 4	T1:6.2 R2:10.3
36	Architecture of 8259 PIC	CO 4	T1:6.2 R2:10.3
38	Keyboard /display controller 8279	CO 6	T1:6.3 R2:10.2
40	Programmable communication interface 8251 USART	CO 5	T1:6.4 R2:11.3
42	DMA Controller 8257	CO 3	T1:7.1 R2:11.6
43	Internal architecture and pin configuration of 8051 microcontroller	CO 1	T1:17.2 R2:20.1
44	Addressing modes of 8051 microcontroller	CO 2	T1:17.3
45	Instruction set of 8051 microcontroller	CO 2	T1:17.8 R2:19.9
46	Bit addressable features and I/O Port structures	CO 1	T1:17.4 R2:19.10
48	8051 Timers/Counters	CO 1	T1:17.5 R2:20.3,20.4
49	Serial data communication and its programming	CO 5	T1:17.6 R2:20.6
50	8051 interrupts, Interrupt vector table	CO 4	T1:17.7 R2:20.5

PROBLEM SOLVING/ CASE STUDIES			
6	Physical address calculation	CO 1	T1:1.1 R2:1.1
20	Assembly language programs For Sorting of numbers using 8086 microprocessor	CO 2	T1:3.4 R2:4.7
21	Assembly language programs for multibyte addition and subtraction, sum of squares using 8086 microprocessor	CO 2	T1:3.4 R2:4.7
22	Assembly language programs for String manipulations using 8086 microprocessor	CO 2	T1:3.4 R2:4.1
23	Assembly language programs for Code conversions using 8086 microprocessor	CO 2	T1:3.4 R2:4.4,4.5
28	Memory interfacing to 8086 microprocessor (Static RAM)	CO 3	T1:5.1 R2:12.2,12.3
29	Memory interfacing to 8086 microprocessor (EPROM)	CO 3	T1:5.2 R2:12.4
32	Interfacing A/D and D/A converters with 8086 microprocessor	CO 6	T1:5.6,5.7 R2:9.8,9.9
34	Assembly language programs to rotate stepper motor in clockwise and anticlock wise direction	CO 2	T1:5.8 R2:9.11
37	Cascading of Interrupt Controller and its importance, interfacing 8259 PIC with 8086 microprocessor	CO 4	T1:6.2 R2:10.3,10.4
39	Interfacing keyboard /display controller 8279 to 8086 microprocessor	CO 6	T1:6.3 R2:10.2
41	Interfacing programmable communication interface 8251 USART to 8086 microprocessor	CO 5	T1:6.4 R2:11.3
47	Assembly language programming using data transfer, arithmetic, logical and branch instructions	CO 2	T1:17.8 R2:19.3
51	Real world interfacing of 8051 microcontroller with external memory	CO 6	T1:17.6 R2:20.2
52	Interfacing 8051 microcontroller with LCD	CO 6	T1:17.9 R2:21.3
53	Interfacing 8051 microcontroller with ADC and DAC	CO 6	T1:17.9 R2:21.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
54	8086 Microprocessor	CO 1, CO 2	T1, R2
55	Programming with 8086 microprocessor	CO 1, CO 2, CO 4	T1, R2
56	Interfacing with 8086/88	CO 2, CO 3, CO 4, CO 5, CO 6	T1, R2
57	8051 microcontroller	CO 1, CO 2,	T1, R2

58	System design using microcontroller	CO 3, CO 4, CO 5, CO 6	T1, R2
DISCUSSION OF QUESTION BANK			
59	8086 Microprocessor	CO 1, CO 2	T1, R2
60	Programming with 8086 microprocessor	CO 1, CO 2, CO 4	T1, R2
61	Interfacing with 8086/88 microprocessor	CO 2, CO 3, CO 4, CO 5	T1, R2
62	8051 microcontroller	CO 1, CO 2	T1, R2
63	System design using microcontroller	CO 3, CO 4, CO 5	T1, R2

Signature of Course Coordinator
Ms B. Lakshmi Prasanna, Assistant Professor **HOD, ECE**

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences **(Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations **(Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions	**10**

	5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**

PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project.	**12**

	6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	
PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**ENERGY AUDIT AND MANAGEMENT**				
Course Code	AEE503				
Program	B.Tech				
Semester	VI				
Course Type	ELECTIVE				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms. B Navothna, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	UG	AEE003	Power Generation Systems
B.Tech	UG	AHS015	Business Economics and Financial Analysis

II COURSE OVERVIEW:

Energy audit and management deals principles of energy audit and conservation. Energy efficiency in buildings energy efficient motors lighting instruments and significance of energy economics. Communication and marketing strategies opportunities for renewable source very good management strategies for conservation giving good motivation for employs maintaining up to date records of audit for effective management it also deals with internal and external bench marking it also deals with energy and material balance.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Energy Audit And Management	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
30%	Remember
40 %	Understand
0%	Apply
30%	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

VI COURSE OBJECTIVES:

The students will try to learn:

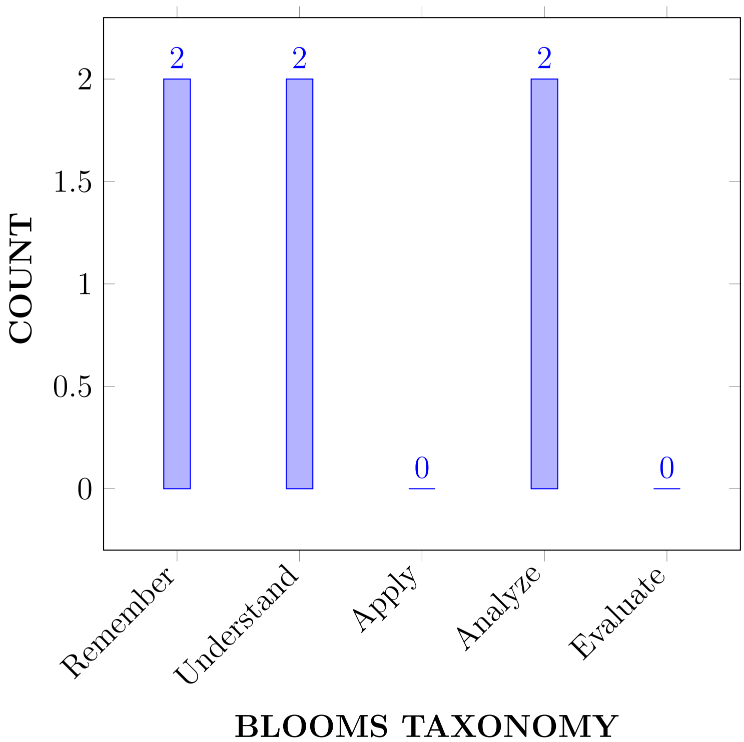
I	Outline the principles and objectives of energy management.
II	Illustrate the techniques, procedures, evaluation and energy audit reporting.
III	Devise energy policy planning and implementation.
IV	Analyse energy balance sheet and management information System.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Demonstrate** knowledge on auditing practices, management measures and economics of energy.	Understand
CO 2	**Solve** energy auditing and management problems with societal relevance	Analyze
CO 3	**Follow** relevant rules and regulations in t practicing energy audit and management	Remember
CO 4	**Analyze** energy balance sheet and management information System	Analyze
CO 5	**Provide** issues and in energy audit and management	Remember
CO 6	**Know** about Instruments for audit and monitoring energy and energy savings, types and accuracy	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/CIE/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	SEE/CIE/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	SEE/CIE/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	SEE/CIE/AAT
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	SEE/CIE/AAT
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	1	SEE/CIE/AAT
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	SEE/CIE/AAT
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	1	SEE/CIE/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.	2	SEE/CIE/AAT
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development.	2	SEE/CIE/AAT

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	✓	-	✓	-	✓	-	✓	✓	-	-
CO 2	✓	✓	-	✓	-	✓	-	✓	-	✓	-	✓	✓	✓	-
CO 3	✓	-	✓	-	-	✓	-	✓	-	✓	-	✓	-	-	-
CO 4	✓	✓	✓	-	-	✓	-	✓	-	✓	-	✓	✓	✓	-
CO 5	✓	-	-	-	-	✓	-	-	-	✓	-	✓	✓	✓	-
CO 6	✓	✓	-	-	-	✓	-	✓	-	✓	-	✓	✓	✓	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** to classify various sources of energys	3
	PO 2	**Identify the problem statement** , select the appropriate source required for generation and transmssion	2
	PO 6	Understand the inject of a voltage in the line with the facts controllers **using science and engineering fundamentals**	3
	PO 8	Understand energy flow in power plants for stable operation of power systems **for using principles of mathematics,science and engineering fundamentals.**	4
	PO 10	Understand the importance of controllers according to the necessities **for communicating effectively with engineering community.**	3
	PO 12	Understand energy flow in cooling towers for stable operation of power systems **the need for and having the preparation and ability to engage in independent and life-long learning in the context of designing.**	4

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 1	Understand the reactance, load impedance performance of the overall electric power system **s used in various stages of utilization of electrical energy.**	3
CO 2	PO 1	Apply the knowledge of different sectors (**scientific Principles and mathematical principles**) for energy efficiency and conservation	3
	PO 2	Determine the role of Buerau of Energy Efficiency **using first principles and Mathematics and Engineering sciences.**	2
	PO 3	Understand the shunt controllers to regulate the transmission voltage **in power systems**	5
	PO 4	Illustrate energy conservation act and its features**using fundamentals of science &and engineering fundamentals**	1
	PO 6	Understand the energy flow in generation systems analysis **according to the necessities**	3
	PO 8	Designing of stratergies in the power system, to regulate the transmission voltage **in power systems**	4
	PO 10	Understand energy conservation stratergies **to regulate power usage in power plant**	3
	PO 12	Understand transient stability enhancement of conservation modles **in power systems**	4
	PSO 1	Understand power oscillation damping of single machine infinite bus system **withcompensator connected at the midpoint of the line.**	3
	PSO 2	Understand energy flow analysis **for modeling of reactors and cooling towers**	7
CO 3	PO 1	Understand the advantages of Energy auditing and security**using fundamentals of science &and engineering fundamentals**	2
	PO 3	Demonstrate the operation, analysis and gate turn off characteristics of Thyristor Controlled Series Capacitor **using with help of engineering sciences.**	5
	PO 6	Recognize the importance of various operating modes of series compensator used in controlled devices **in power systems**	3
	PO 8	Focus on working as a member or leader in designing the inverter circuits **by individual and team work.**	4
	PO 10	Recognize the role of modulation techniques in outputvoltage control of energy **by communicating effectively with engineering community.**	3
	PO 12	Recognize the need for and having the preparation and ability to engage in independent and life-long learning **in the context of modeling of TCSC**	4
CO 4	PO 1	Analyze energy efficient technologies for industrial applications **using fundamentals of science &and engineering fundamentals.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Categorize the instruments based on the components used **complex engineering problems.**	3
	PO 3	Investigate and define a problem and identify constraints of energy consumption and peak demand **environmental and sustainability limitations, health and safety and risk assessment issues** when dealing with performance of gaseous mixtures and their application on real world problems	2
	PO 4	Modelthe industrial applications involves power flow studies which include the calculation of bulbar voltage, branch loadings, and real, reactive transmission losses according to the necessities. **according to the necessities**	6
	PO 6	Control Control both real- and reactive power flows **in a transmission**	3
	PO 9	Understand Focus on working as a member or leader in designing of towers).**in transmition network**	4
	PO 10	Understand power system transient stability improvement **by means of energy audit princiciples in power systems**	3
	PO 12	Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the context of designing **the need for and having the preparation and ability to engage in independent and life-long learning in the context of designing**	4
	PSO 1	Design the converter circuits to perform AC-AC conversion to achieve desired voltage output and interpret **the results through simulation and hardware implementation.**	7
	PSO 2	Make use of the protection and commutation techniques for the circuits associated with power electronic devices**for smooth operation while energy conversion**	3
CO 5	PO 1	Describe (**Knowledge**) performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities **using principles of mathematics, natural science, and engineering fundamentals.**	3
	PO 6	Understand The interaction phenomena are investigated as functions of electrical coupling between the SVCs and the short-circuit level at the SVC buses. **with responsibilities relevant to the professional engineering practice**	3
	PO 10	Recognize Co-Ordination of multiple Controllers using Non Linear – Control Techniques **Co-Ordination of multiple Controllers using Non Linear – Control Techniques**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 12	Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the context of optimal selection of power devices.	4
	PSO 1	Understand Electromechanical-oscillation interactions between FACTS controllers **also involve synchronous generators, compensator machines, and associated powersystem stabilizer controls**	3
	PSO 2	Outline co ordination of control techniques to **requirements of the employer**	7
CO 6	PO 1	Evaluate the performance Automatic power factor controllers, energy efficient motors **understanding of engineering science and mathematical equations**	3
	PO 2	**Identify the problem statement** (mission requirement), efficient transformers, electronic ballast (**information and data collection**) suitable to mission requirement	2
.	PO 6	Understand the inject of a voltage in the line with the facts controllers **using science and engineering fundamentals**	3
	PO 8	Understand power flow in transmission lines for stable operation of power systems **for using principles of mathematics,science and engineering fundamentals.**	4
	PO 10	Understand the importance of controllers according to thenecessities **for communicating effectively with engineering community.**	3
	PO 12	Understand power flow in transmission lines for stable operation of power systems **the need for and having the preparation and ability to engage in independent and life-long learning in the context of designing.**	4
	PSO 1	Understand the reactance, load impedance performance of the overall electric power system **s used in various stages of utilization of electrical energy.**	3
	PSO 2	Assessment of cooling towers. **understand the innovative and dynamic challenges** involve the guidance system for specific role.	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	-	-	-	2	-	2	-	2	-	4	1	-	-
CO 2	3	2	-	-	-	2	-	2	-	2	-	4	1	1	-
CO 3	3	-	2	-	-	2	-	2	-	2	-	4	-	-	-
CO 4	3	4	2	2	-	2	-	2	-	2	-	4	1	1	-

CO 5	3	-	-	-	-	2	-	-	-	2	-	4	1	1	-
CO 6	3	2	-	-	-	2	-	2	-	2	-	4	1	1	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	30	-	-	-	100	-	66.7	-	40	-	55	55	-	-
CO 2	100	20	-	40	-	100	-	66.7	-	40	-	55	55	63	-
CO 3	100	-	20	-	-	100	-	66.7	-	40	-	55	-	-	-
CO 4	100	40	20	20	-	100	-	66.7	-	40	-	55	55	63	-
CO 5	100	-	-	-	-	100	-	-	-	40	-	55	55	63	-
CO 6	100	20	-	-	-	100	-	66.7	-	40	-	55	55	63	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -5 $< C \leq 40\%$ – Low/ Slight

2 - 40 % $< C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	2	-	2	-	2	-	2	2	-	-
CO 2	3	2	-	2	-	2	-	2	-	2	-	2	2	2	-
CO 3	3	-	2	-	-	2	-	2	-	2	-	2	-	-	-
CO 4	3	1	2	-	-	2	-	2	-	2	-	2	2	2	-
CO 5	3	-	-	-	-	2	-	-	-	2	-	2	2	2	-
CO 6	3	3	-	2	-	2	-	2	-	2	-	2	2	2	-
TOTAL	**18**	**8**	**4**	**4**	**0**	**12**	**0**	**10**	**0**	**12**	**0**	**12**	**10**	**8**	**0**
AVERAGE	**3**	**2**	**2**	**2**	**0**	**2**	**0**	**2**	**0**	**2**	**0**	**2**	**2**	**2**	**0**

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments	✓				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**GENERAL ASPECTS**
	General philosophy: Need of energy audit and management, definition and objective of energy management, general principles of energy management, energy management skills, energy management strategy; Energy audit: need, types, methodology and approach, energy management approach, understanding energy costs, bench marking, energy performance, matching energy usage to requirements, maximizing system efficiency, optimizing the input energy requirements, fuel and energy substitution.
MODULE II	**PROCEDURES AND TECHNIQUES , EVALUATION OF SAVING OPPURTUNITIES AND ENERGY AUDIT REPORTING**
	Data gathering: Level of responsibilities, energy sources, control of energy and uses of energy, facts, figures and impression about energy / fuel and system operations, past and present operating data, special tests, questionnaire for data gathering; Techniques: Incremental cost concept, mass and energy balancing techniques, inventory of energy inputs and rejections; Evaluations: Heat transfer calculations, evaluation of electric load characteristics, process and energy system simulation, determining the savings in Rs, noneconomic factors, conservation opportunities, estimating cost of implementation; Audit report: The plant energy study report, importance, contents, effective organization, report writing and presentation.
MODULE III	**ENERGY POLICY PLANNING AND IMPLEMENTATION**
	Policy planning: Force field analysis, energy policy purpose, perspective, contents and formulation, location of energy manager, top management support, managerial functions, role and responsibilities of energy manager, accountability. Motivating: Motivation of employees, requirements for energy action planning; Implementation: Designing, barriers, strategies, marketing and communicating training and planning.
MODULE IV	**ENERGY BALANCE AND MIS**
	Energy balance: First law of efficiency and second law of efficiency, facility as an energy system, methods for preparing process flow, materials and energy balance diagram, identification of losses, improvements; MIS: Energy balance sheet and management information system (MIS) energy modeling and optimization.
MODULE V	**ENERGY AUDIT INSTRUMENTS**
	Instruments: Instruments for audit and monitoring energy and energy savings, types and accuracy.

TEXTBOOKS

1. W R Murphy, G Mckay, “Energy Management”, Butterworth’s, 2nd Edition, 2009.
2. C B Smith, “Energy Management Principles”, Pergamon Press, 2nd Edition, 1981.
3. I G C Dryden, “Efficient Use of Energy”, Butterworths, 1st Edition, 1982.
4. AV Desai, “Energy Economics”, Wiley Eastern, 1st Edition, 1991.

REFERENCE BOOKS:

1. D A Reay, “Industrial Energy Conservation”, Pergammon Press, 1st Edition, 1977.
2. W C Turner, “Energy Management Handbook, John Wiley and Sons, 6th Edition , 2006.
3. L C Witte, P S Schmidt, D R Brown, “Industrial Energy Management and Utilization”,Hemisphere Publication, Washington, 1st Edition, 1988.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112105171/1

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO’s	Reference
	OBE DISCUSSION		
0	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
	CONTENT DELIVERY (THEORY)		
1	General philosophy: Need of energy audit and management	CO1	T1:4.1 T2:1.1
2	Definition and objective of energy management	CO1	T1:4.2 T2:1.6
3	General principles of energy management	CO1	T1:4.3 T2:1.7
4	Energy management skills	CO1	T1:4.3 T2:1.8
5	Energy management strategy	CO1	T1:4.5 T2:1.9
6	Need of Energy audit	CO1	T1:4.6 T2:1.10
7	Types	CO1	T1:4.7 T2:1.11
8	Methodology and approach	CO1	T1:4.8 T2:1.12
9	Energy management approach	CO1	T1:4.9 T2:1.13
10	Understanding energy costs	CO2	T1:4.10 T2:1.14
11	Bench marking, energy performance .	CO2	T1:4.11 T2:1.14
12	Matching energy usage to requirements	CO2	T1:4.12 T2:1.15
13	Maximizing system efficiency, optimizing the input energy requirements	CO2	T1:5.1 T2:2.2
14	Fuel and energy substitution	CO2	T1:5.2 T2:2.3

15	Data gathering: Level of responsibilities, energy sources, control of energy and uses of energy, facts, figures and impression about energy / fuel and system operations, past and present operating data.	CO3	T1:5.3 T2:2.4
16	Special tests, questionnaire for data gathering;	CO3	T1:5.4 T2:2.5
17	Techniques: Incremental cost concept, mass and energy	CO3	T1:5.5 T2:2.6
18	Balancing techniques, inventory of energy inputs and rejections;	CO3	T1:5.6 T2:2.7
19	Evaluations: Heat transfer calculations	CO3	T1:5.7 T2:2.8
20	Evaluation of electric load characteristics, process and energy system simulation,	CO3	T1:6.1 T2:3.1
21	Determining the savings in Rs, noneconomic factors	CO3	T1:6.2 T2:3.2
22	Conservation opportunities, estimating cost of implementation;	CO3	T1:6.3 T2:3.4
23	Audit report: The plant energy study report, importance, contents, effective organization, report writing and presentation.	CO3	T1:6.4 T2:3.5
24	Energy balance: First law of efficiency and second law of efficiency	CO3	T1:6.5 T2:3.6
25	Energy balance diagrams	CO3	T1:6.6 T2:3.7
26	Facility as an energy system	CO4	T1:6.7 T2:3.8
27	Methods for preparing process flow	CO4	T1:6.8 T2:3.9
28	Materials and energy balance diagram	CO4	T1:6.9 T2:4.0
29	Identification of losses, improvements;	CO4	T1:7.1 T2:4.1
30	MIS: Energy balance sheet and management information system (MIS) energy	CO4	T1:7.2 T2:4.2
31	Modeling and optimization.	CO4	T1:7.3 T2:4.3
32	Motor replacement issues, energy saving opportunities with energy efficient motors.	CO4	T1:7.1 T2:4.2
33	Energy efficiency in industrial systems	CO5	T1:7.1 T2:4.3
34	Energy efficiency in Compressed air system	CO5	T1:7.5 T2:4.1
35	Energy efficiency in Fans and blowers	CO5	T1:7.8 T2:4.2
36	Instruments	CO6	T1:8.1 T2:4.3

37	Instruments for audit	CO6	T1:8.2 T2:4.5
38	Monitoring energy	CO6	T1:8.3 T2:5.1
39	Energy savings	CO6	T1:11.1 T2:6.1
40	Types and accuracy	CO6	T1:11.2 T2:6.2
PROBLEM SOLVING/ CASE STUDIES			
41	Case Studies: Energy generation and security	CO1	T1:4.3 T2:1.7
42	Case studies for the energy sector	CO1	T1:4.3 T2:1.7
43	Energy Conservation and Renewable Energy Case Studies	CO2	T1:4.3 T2:1.7
44	Case Study on Generation of Biomass Energy Using Agriculture Residue	CO2	T1:5.1
45	Renewable Energy For A Manufacturing Facility	CO3	T1:5.2
46	Solar PV Diversification Strategy for an Indian Multinational	CO4	T1:5.3
47	Indian Market Entry Strategy for a German Solar PV Firm	CO5	T1:5.4
48	Case studies in Cloud services of Internet services	CO5	T1:5.5
49	Energy Conservation And Audit-A Case Study	CO6	T1:5.6
50	A Case Study on Energy Conservation & Audit for Household Applications	CO6	T1:5.7
51	Case Studies for the Energy Efficiency Program	CO5	T1:5.8
52	Case study on energy auditing	CO5	T1:5.8
53	Energy Audit: Case Study of A Wheel Manufacturing Industry	CO5	T1:6.1
54	Energy Audit of an Industrial Site: A Case Study	CO8	T1:6.8
55	Energy Audit Of A Boiler- A Case Study Thermal Power Plant, Unit-III Parli (V) Maharastra.	CO5	T1:8.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	India energy scenario and types of energy sources	CO1	T1:7.1 T2:4.1
57	Material and Energy balance	CO2	T1:6.6 T2:3.7
58	Electricity billing, electrical load management	CO3	T1:6.9 T2:4.0
59	Factors of performance and savings opportunities in HVAC	CO8	T1:8.1 T2:4.3
60	Soft starters with energy saver	CO 6	T1:11.2 T2:6.2
DISCUSSION OF QUESTION BANK			
61	General aspects	CO1	T1:4.5
62	Procedures and techniques , evaluation of saving oppurtunities and energy audit reporting	CO2	T1:6.6 T2:3.7

63	Energy policy planning and implementation	CO3	T1:6.9 T2:4.0
64	Energy balance and mis	CO5	T1:8.1 T2:4.3
65	Energy audit instruments	CO6	T1:11.2 T2:6.2

Signature of Course Coordinator **HOD,EEE**

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF(s)
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences **(Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations **(Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions	**10**

	5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**

PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project.	**12**

	6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	
PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**

PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer. 1. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRON ICS ENGINEERING

COURSE DESCRIPTION

Course Title	SOLID STATE ELECTRIC MOTOR DRIVES LABORATORY				
Course Code	AEE109				
Program	B.Tech				
Semester	VI	EEE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Mr. P. Shivakumar, Assistant Professor				

I COURSE OVERVIEW:

The aim of this course is to conduct experiments on AC and DC drives. Control of DC motor drives with single phase and three phase converters and choppers are to be studied. The control of AC motor drives with variable frequency converters and variable voltage are to be conducted.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE004	III	DC machines
B.Tech	AEE007	IV	AC machines
B.Tech	AEE010	V	Power Electronics

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Solid state electric motor drives laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner,

both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	-
20 %	Analysis	-
20 %	Design	-
20 %	Conclusion	-
20 %	Viva	-

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
-	-	-	-	-	-

VI COURSE OBJECTIVES:

The students will try to learn:

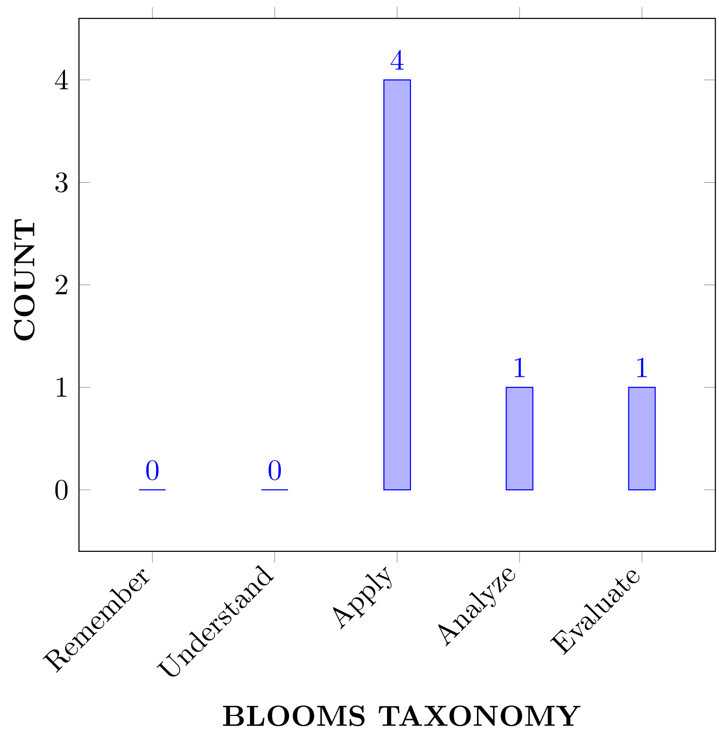
I	Apply principles of power electronics in speed control of various drives.
II	Demonstrate the concept of four quadrant operations of drives.
III	Discuss various drives used in industries to control torque and speed.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Make use of** single phase and three phase rectifiers for Speed control of DC shunt motor. .	Apply
CO 2	**Analyze** operation of PMDC motor using thyristor drive and chopper for measuring speed.	Apply
CO 3	**Demonstrate** various speed control methods of AC Motors using AC voltage controller and Variable Frequency Drive..	Analyze
CO 4	**Examine** operation of DC Jones Chopper circuit and potentiometer for different load conditions	Apply
CO 5	**Analyze** speed characteristics of special machines using MATLAB	Evaluate
CO 6	**Examine** operation of Simulation of BLDC motor drive using MATLAB	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Program Outcomes	
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	Lab Exercises

PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3	Lab Exercises
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	Lab Exercises
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	Lab Exercises
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	3	Lab Exercises
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Lab Exercises
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Lab Exercises
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	2	Lab Exercises

PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	2	Lab Exercises
PSO 3	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Observe the functionality of power electronic components for static voltage current characteristics using **principles of mathematics and engineering science**	2
	PO 2	Understand the given power electronic components application **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the given power electronic components voltage current characteristics **for design solutions of complex engineering problems**	6
	PO 4	Understand the given power electronic components characteristics **with analysis and interpretation of data**	6
	PO 6	Illustrate the given power electronic component operation **for safety issues in professional engineering practice**	4
	PO 8	Understand the given power electronic components characteristics **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the given power electronic components operation **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the power electronic components operation **with communication of complex engineering practices**	3
	PO 12	Understand the given power electronic components application **in life long learning in technological change**	6
	PSO 1	Demonstrate the given power electronic components application **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the given power electronic components application **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the given power electronic components application **in automation process using PLC and process controllers**	4

CO 2	PO 1	Observe the functionality of forced commutation circuits and gate firing circuits using **principles of mathematics and engineering sciences**	2
	PO 2	Understand the forced commutation circuits and gate firing circuits with**problem statement by analyzing complex engineering problems.**	6
	PO 3	Develop the forced commutation circuits and gate firing circuits **for design solutions of complex engineering problems**	6
	PO 4	Understand the forced commutation circuits and gate firing circuits operation **with analysis and interpretation of data**	6
	PO 6	Illustrate the forced commutation circuits and gate firing circuits **for safety issues in professional engineering practice**	4
	PO 8	Understand the forced commutation circuits and gate firing circuits **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the forced commutation circuits and gate firing circuits **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the turn on and turn off methods of SCR **with communication of complex engineering practices**	3
	PO 12	Understand the forced commutation circuits and gate firing circuits **in life long learning in technological change**	6
	PSO 1	Demonstrate the forced commutation circuits and gate firing circuits **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the forced commutation circuits and gate firing circuits **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the forced commutation circuits and gate firing circuits **in automation process using PLC and process controllers**	4
CO 3	PO 1	Observe the input and output waveforms of controlled rectifier circuits using **principles of mathematics and engineering science**	2
	PO 2	Understand the operation of controlled rectifier circuits **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the controlled rectifier circuits **for design solutions of complex engineering problems**	6
	PO 4	Understand the input and output waveforms of controlled rectifier circuits **with analysis and interpretation of data**	6

	PO 5	Understand the controlled rectifier circuits **modelling using IT tools such as MATLAB**	6
	PO 6	Illustrate the input and output waveforms of controlled rectifier circuits **for safety issues in professional engineering practice**	4
	PO 8	Understand the input and output waveforms of controlled rectifier circuits **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the controlled rectifier circuits operation **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the input and output waveforms of controlled rectifier circuits **with communication of complex engineering practices**	3
	PO 12	Understand the controlled rectifier circuits operation **in life long learning in technological change**	6
	PSO 1	Demonstrate the input and output waveforms of controlled rectifier circuits **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the controlled rectifier circuits applications **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the operation of controlled rectifier circuits **in automation process using PLC and process controllers**	4
CO 4	PO 1	Observe the various inverter circuits for direct current to Alternating current conversion using **principles of mathematics and engineering science**	2
	PO 2	Understand the operation of various inverter circuits **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the inverter circuits **for design solutions of complex engineering problems**	6
	PO 4	Understand the various inverter circuits for direct current to Alternating current conversion **with analysis and interpretation of data**	6
	PO 5	Understand the inverter circuits **modelling using IT tools such as MATLAB**	6
	PO 6	Illustrate the various inverter circuits for direct current to Alternating current conversion **for safety issues in professional engineering practice**	4
	PO 8	Understand the various inverter circuits for direct current to Alternating current conversion **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the inverter circuits operation **to function effectively as an individual and as a member in team**	8

	PO 10	Interpret the various inverter circuits for direct current to Alternating current conversion **with communication of complex engineering practices**	3
	PO 12	Understand the inverter circuits operation **in life long learning in technological change**	6
	PSO 1	Demonstrate the operation of inverter circuits **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the inverter circuits applications **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the operation of inverter circuits **in automation process using PLC and process controllers**	4
CO 5	PO 1	Observe the performance characteristics of ac to ac converters using **principles of mathematics and engineering science**	2
	PO 2	Understand the operation of AC voltage controllers and cycloconverters **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the operation of AC voltage controllers and cycloconverters **for design solutions of complex engineering problems**	6
	PO 4	Understand the operation of AC voltage controllers and cycloconverters **with analysis and interpretation of data**	6
	PO 6	Illustrate the performance characteristics of ac to ac converters **for safety issues in professional engineering practice**	4
	PO 8	Understand the performance characteristics of ac to ac converters **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the operation of AC voltage controllers and cycloconverters **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the operation of AC voltage controllers and cycloconverters **with communication of complex engineering practices**	3
	PO 12	Understand the AC voltage controllers and cycloconverters applications **in life long learning in technological change**	6
	PSO 1	Demonstrate the AC voltage controllers and cycloconverters applications **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the AC voltage controllers and cycloconverters applications **in electrical drives with converter topologies for energy conversion and management**	7

	PSO 3	Illustrate the operation AC voltage controllers and cycloconverters applications **in automation process using PLC and process controllers**	4
CO 6	PO 1	Observe the chopper circuits operation using **principles of mathematics and engineering science**	2
	PO 2	Understand the operation of chopper circuits **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the chopper circuits **for design solutions of complex engineering problems**	6
	PO 4	Understand the various chopper circuits for dc to variable dc conversion **with analysis and interpretation of data**	6
	PO 5	Understand the chopper circuits **modelling using IT tools such as MATLAB**	6
	PO 6	Illustrate the chopper circuits for dc to varible dc conversion **for safety issues in professional engineering practice**	4
	PO 8	Understand the chopper circuits for dc to varible dc conversion **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the chopper circuits operation **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the the chopper circuits for dc to varible dc conversion **with communication of complex engineering practices**	3
	PO 12	Understand thechopper circuits operation **in life long learning in technological change**	6
	PSO 1	Demonstrate the operation of chopper circuits **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the chopper applications **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the operation of chopper circuits **in automation process using PLC and process controllers**	4

XII MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	3	3	-	2	-	3	2	2	-	2	2	3	3
CO 2	3	3	3	3	-	2	-	3	2	2	-	2	2	3	3
CO 3	3	3	3	3	3	2	-	3	2	2	-	2	2	3	3
CO 4	3	3	3	3	3	2	-	3	2	2	-	2	2	3	3

CO 5	3	3	3	3	-	2	-	3	2	2	-	2	2	3	3
CO 6	3	3	3	3	3	2	-	3	2	2	-	2	2	3	3

XIII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIV ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XV SYLLABUS:

WEEK I	**SINGLE PHASE RECTIFIER FED DC SHUNT MOTOR**
	Speed control of DC shunt motor using single phase rectifier
WEEK II	**THREE PHASE RECTIFIER FED DC SEPARATELY EXCITED MOTOR**
	Speed control of DC separately excited shunt motor using three phase rectifier.
WEEK III	**SPEED MEASUREMENT AND CLOSED LOOP CONTROL OF PMDC MOTOR**
	Speed measurement and closed loop control of PMDC motor using thyristorized and MOSFET based chopper drive.
WEEK IV	**FOUR QUADRANT CHOPPER DRIVE**
	Four quadrant operation of PMDC motor using chopper.
WEEK V	**AC VOLTAGE CONTROLLER FED INDUCTION MOTOR**
	Speed control of induction motor using AC voltage controller
WEEK VI	**DC JONES CHOPPER**
	Verification of DC Jones chopper
WEEK VII	**SPEED CONTROL OF DC MOTOR**
	Speed control of DC motor with external contacts and potentiometer arrangement.
WEEK VIII	**SYNCHRONOUS MOTOR SPEED CONTROL**
	Speed control of synchronous motor using VFD
WEEK IX	**SPEED CONTROL OF STEPPER MOTOR USING DIGITAL SIMULATION**
	Stepper motor speed control using MATLAB.
WEEK X	**UNIVERSAL MOTOR SPEED CONTROL USING DIGITAL SIMULATION**
	Universal motor speed control using MATLAB

WEEK XI	**SVPWM CONTROL OF INDUCTION MOTOR USING DIGITAL SIMULATION**
	SVPWM CONTROL OF INDUCTION MOTOR USING DIGITAL SIMULATION SVPWM VSI fed induction motor drive simulation using MATLAB
WEEK XII	**DIRECT TORQUE CONTROL OF INDUCTION MOTOR DRIVE USING DIGITAL SIMULATION**
	Direct torque control of induction motor drive simulation using MATLAB
WEEK XIII	**FOUR QUADRANT OPERATION OF DC MOTOR USING DIGITAL SIMULATION**
	Four quadrant operation of DC drives with three phase converter simulation using MATLAB.
WEEK XIV	**BLDC MOTOR DRIVE USING DIGITAL SIMULATION**
	Simulation of BLDC motor drive using MATLAB

TEXTBOOKS

1. G K Dubey, "Fundamentals of Electric Drives", Narosa Publications, 2nd Edition, 2001.
2. B K Bose, "Modern Power Electronics and AC Drives", Prentice Hall India Learning Private Limited, 2005.

REFERENCE BOOKS:

1. P S Bimbhra, "Power Electronics", Khanna Publishers, 5th Edition, 2012.
2. G K Dubey, S R Doradra, A Joshi, R M K Sinha, "Thyristorised Power Controllers", New Age International Limited, 2nd Edition, 2008.
3. M D Singh, K B Kanchandhani, "Power Electronics", Tata Mc Graw Hill Publishing Company, 7th Edition, 2007.

XVI COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Study the speed torque characteristics of DC shunt motor using single phase rectifier..	CO 1	T1:3.1
2	Study the Speed torque characteristics of DC separately excited shunt motor using three phase rectifier.	CO 2	T1:3.11
3	Study the closed loop control of PMDC motor using thyristorized and MOSFET based chopper drive.	CO 3	T1:4.8
4	Study the four quadrant operation of PMDC motor using chopper.	CO 2	T1:4.8
5	Study the characteristics of induction motor using AC voltage controller.	CO 3	T1.5.5
6	Verify the characteristics of DC Jones chopper	CO 4	T1:5.6
7	Study the speed control of DC motor with external contacts and potentiometer arrangement.	CO 4	T1:8.3
8	Plot the characteristics of synchronous motor using VFD	CO 5	T1:8.3

9	Study the principle of operation of stepper motor using MATLAB	CO 3	T1:9.2
10	Study the principle of operation of universal motor using MATLAB	CO 5	T1:9.3
11	Verify the characteristics of SVPWM VSI fed induction motor drive simulation using MATLAB	CO 3	T1:10.6
12	Verify direct torque control of induction motor drive simulation using MATLAB	CO 6	T1:10.7
13	Verify four quadrant operation of DC drives with three phase converter simulation using MATLAB	CO 3	T1:10.7
14	Simulation of BLDC motor drive using MATLAB	CO 6	T1:10.8

Signature of Course Coordinator **HOD, EEE**
Mr. P.Shivakumar, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**

PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**

PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**

PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**
PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**
PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer. 1. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRONICS ENGINEERING
COURSE DESCRIPTION

<table>
<tr><td>Course Title</td><td colspan="5">PLC AND AUTOMATION LABORATORY</td></tr>
<tr><td>Course Code</td><td colspan="5">AEE110</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td>VI</td><td colspan="4">EEE</td></tr>
<tr><td>Course Type</td><td colspan="5">Core</td></tr>
<tr><td>Regulation</td><td colspan="5">IARE - R16</td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>3</td><td>2</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Mr. P Mabuhussain, Assistant Professor, EEE</td></tr>
</table>

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE007	IV	AC Machines
B.Tech	AEE008	IV	Electrical Measurements and Instrumentation

II COURSE OVERVIEW:

The objective of this laboratory course is to measure, analyze and control the physical input and outputs like temperature, speed, voltage, current, etc., in an industrial automation process using programmable logic controllers (PLCs). The lab emphasizes on the software and hardware skills to design and realize an automation process. The lab is mainly intended to give hands-on skills on PLCs to implement software timers, counters and their usage in traffic signal control, lift control, sequential control, solar tracking, starting and braking of electrical machines.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
PLC and Aautomation Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

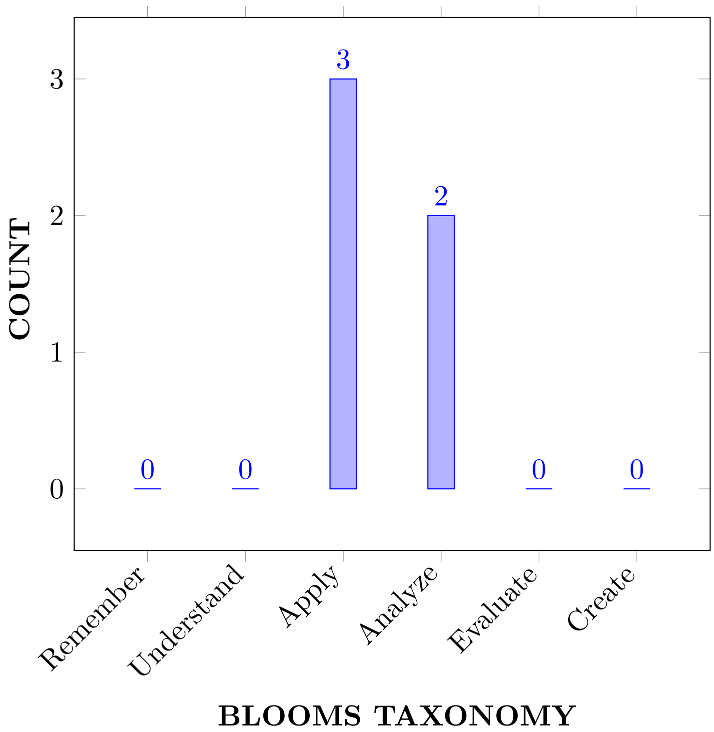
I	The functioning of programmable logic controller (PLC), its I/O modules and usage of these devices in an automation system.
II	The interfacing of input and output devices of a process with PLC and control of these devices automatically.
III	The programming of PLC using relay ladder diagram programming method and interfacing of PLC with Human Machine Interface (HMI) and Variable Frequency Drive (VFD).

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Use** PLC timers and Counters for delaying a particular control process and counting the production rate in an industrial system.. .	Analyze
CO 2	**Design** a system for starting, speed control and braking of DC/AC motors using PLC digital module.	Apply
CO 3	**Measure** the temperature, speed, voltage and current using PLC analog module to control the operation of motors, relays and circuit breakers.	Analyze
CO 4	**Construct** PLC based automatic traffic signal system to control the vehicle congestion at a three-way or four-way road junction.	Apply
CO 5	**Develop** the ladder diagram logic programs for lift control, solar tracking and fault annunciation systems.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX PROGRAM SPECIFIC OUTCOMES:

Program Specific Outcomes	
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.
PSO 3	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.

X HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises /CIE / SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Lab Exercises /CIE / SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	Hands on practice /CIE / SEE
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Hands on practice /CIE / SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations.	3	Lab Exercises / CIE / SEE
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	Lab Exercises / CIE / SEE

PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	3	Lab Exercises / CIE / SEE
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	Lab Exercises / CIE / SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	3	Lab Exercises / CIE / SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2	Lab Exercises / CIE / SEE

3 = High; 2 = Medium; 1 = Low

XI HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.	2	Hands on practice /CIE / SEE
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	2	Hands on practice /CIE / SEE
PSO 3	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.	3	Hands on practice /CIE / SEE

3 = High; 2 = Medium; 1 = Low

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	**Justification for mapping (Students will be able to)**	No. of Key Competencies
CO 1	PO 1	**Classify** the various software timers and counters according to their usage by basic **mathematical principles** and **apply** them in an industrial process.	3
	PO 2	**Use** the Delta make WPLsoft software for writing the ladder diagram for on-delay, off-delay and up and updown counters for a particular process in an industry.	4

	PO 4	**Design** the real time experiments using the software timers and counters by applying the principles of engineering sciences	4
	PO 5	**Use** the Delta make WPLsoft software for writing the ladder diagram for on-delay, off-delay used for delaying a particular operation of a process in an industry and counters for counting the number of products produced.	1
	PO 6	**Apply** the timers and counters for protecting a system in an industry and provide the safety to the people and industry personnel.	2
	PO 8	**Write** the worksheets after completion of an experiment in laboratory by following the ethical principles	2
	PO 9	**Make use of** a team of members and function effectively and do the experiment in the laboratory .	8
	PO 10	**Wrtie** the worksheets for a particulary laboratory experiment and asnwers theviva voce questions asked by the laboratory incharge and some times even give a seminar on a topic given by the subject teacher.	4
	PO 12	**Recognize** the need of programmable logic controllers in an industrial automation system and gain the knowledge in the laboratory and use it in life long technical change.	5
	PSO 3	**Explicit** the software timers in Delta make WPLsoft software and **adopt** them to **program** a PLC used in an industrial automation process	5
CO 2	PO 1	**Remembe**r the starting methods, speed control methods and braking methods of an induction motor using the **electrical engineering scientific principles and methodologies** and **apply** them to control the motor.	3
	PO 2	**Understand** the purpose of using a motor in an industrial process and **state the problem** and **identify and apply** the appropriate solution either to start or brake the motor or to control the speed of motor.	4
	PO 3	**Analyze** the starting, speed control and braking of induction motor using programmable logic controllers	3
	PO 5	**Write** a ladder diagram program in WPLSoft software using relevant contactors and timers to start, control and brake the three phase induction motor.	1
	PO 6	**Apply** the timers and counters for protecting a system in an industry and provide the safety to the people and industry personnel.	2
	PO 8	**Write** the worksheets after completion of an experiment in laboratory by following the ethical principles	2
	PO 9	**Make use of** a team of members and function effectively and do the experiment in the laboratory .	8
	PO 10	**Wrtie** the worksheets for a particulary laboratory experiment and asnwers theviva voce questions asked by the laboratory incharge and some times even give a seminar on a topic given by the subject teacher.	4

	PSO 2	**Focus** on the components required for designing a speed control or braking method for a motor using the principles of engineering sciences and mathematics..	4
	PSO 3	**Gain** the Hands-on skills on PLc and HMI and how to interface them with the motor and control the motor accordingly	5
CO 3	PO 1	**Understand** the measuring principles of temperature, speed, current, voltage etc., using the **engineering principles** and **appl**y them to control a certain process in an industry.	3
	PO 2	**Identify the problem** of a process in an industry and **analyze** it to select a suitable motor using the **principles of engineering.**	4
	PO 4	**investigate** a process in an industry and **analyze** it to select a suitable starting or braking method for a motor using the **principles of engineering.**	6
	PO 5	**Develop** a ladder diagram program to start, control or brake a three phase induction motor using a WPLSoft software.	1
	PO 6	**Apply** the timers and counters for protecting a system in an industry and provide the safety to the people and industry personnel.	2
	PO 8	**Write** the worksheets after completion of an experiment in laboratory by following the ethical principles	2
	PO 9	**Make use of** a team of members and function effectively and do the experiment in the laboratory .	8
	PO 10	**Wrtie** the worksheets for a particulary laboratory experiment and asnwers theviva voce questions asked by the laboratory incharge and some times even give a seminar on a topic given by the subject teacher.	4
	PO 12	**Recognize** the need of programmable logic controllers in an industrial automation system and gain the knowledge in the laboratory and use it in life long technical change.	5
	PSO 1	**Design** a control system for control of voltage, current, temperature and speed of motro with in the prescribed limits	2
	PSO 2	**Focus** on the components required or sensors required for controlling of different physical parameters like temperature, speed etc.	5
	PSO 3	**Interface** the various types of sensors with PLC to measure the analog input quantities like temperature, speed, voltage, current etc., **analyze** the working of software tools and get the hands-on skills of using them.	5
CO 4	PO 1	**Understand** the traffic signal control process using **basic scientific principles.**	3

	PO 2	**Anlayze** the traffic at a particular location, **understand** the need of traffic signals and **design** a system that controls the traffic lights at a three way or four way road junctions to ensure the **safety of public.** .	4
	PO 5	**Use** the Delta make WPLsoft software and write the ladder diagram program to control the traffic lights at a road junction with more accurately and precisely.	1
	PO 6	**Apply** the timers and counters for protecting a system in an industry and provide the safety to the people and industry personnel.	2
	PO 8	**Write** the worksheets after completion of an experiment in laboratory by following the ethical principles	2
	PO 9	**Make use of** a team of members and function effectively and do the experiment in the laboratory .	8
	PO 10	**Wrtie** the worksheets for a particulary laboratory experiment and asnwers theviva voce questions asked by the laboratory incharge and some times even give a seminar on a topic given by the subject teacher.	4
	PSO 3	**Gain** the hands-on skills on PLC, HMI and construct a traffic signal control system for a three way or four way juction	5
CO 5	PO 1	**Understand** the operation of a temperature control system, solar tracking system and electrical fault detection system using the **electrical engineering principles and methodologies.**	3
	PO 2	**Analyze** the operation of a temperature control system, solar tracking system and electrical fault detection system using the **electrical engineering principles and methodologies.** and solve the problems associated with those systems	4
	PO 3	**Identify** the purpose of a temperature control system in an industry and **design** a system which maintains the temperature within specified limits. Also, **measure** and **analyze** the electrical current and voltage taken by the equipment in industry and **develop** a system which makes these variables within limits.	3
	PO 5	**Interface** the temperature sensor, proximity sensor, potential transformer and current r transformer with PLC and write a relay ladder logic in WPLsoft software to measure temperature, speed, voltage and currents.	1
	PO 6	**Apply** the timers and counters for protecting a system in an industry and provide the safety to the people and industry personnel.	2
	PO 8	**Write** the worksheets after completion of an experiment in laboratory by following the ethical principles	2
	PO 9	**Make use of** a team of members and function effectively and do the experiment in the laboratory .	8

	PO 10	**Wrtie** the worksheets for a particulary laboratory experiment and asnwers theviva voce questions asked by the laboratory incharge and some times even give a seminar on a topic given by the subject teacher.	4
	PSO 2	**Use** the thyristror drive for conversion of AC to DC and feed it to DC motor for controlling the speed of DC motor.	5
	PSO 3	**Gain** the hands-on skills PLC, HMI and opertion of temperature control system, fault annuonciation system and solar tracking system	5

XIII MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO's		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	1	3	2	-	3	3	3	-	3	-	-	3
CO 2	3	2	1	-	3	2	-	3	3	3	-	-	-	1	3
CO 3	3	2	-	2	3	2	-	3	3	3	-	3	2	2	3
CO 4	3	2	-	-	3	2	-	3	3	3	-	-	-	-	3
CO 5	3	2	1	-	3	2	-	3	3	3	-	-	-	2	3

XIV ASSESSMENT METHODOLOGY - DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XV ASSESSMENT METHODOLOGY- INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVI SYLLABUS:

WEEK I	**STAR - DELTA STARTER**
Star-delta starter for 3- phase squirrel cage induction motor using programmable logic controller.	
WEEK II	**AUTOMATIC FORWARD AND REVERSE CONTROL**
Automatic forward and reverse control of 3- phase induction motor using PLC.	

WEEK III	FAULT ANNUNCIATION SYSTEM
Fault annunciation system using programmable logic controller.	
WEEK IV	TEMPERATURE CONTROL SYSTEM
Temperature control system using programmable logic controllers and PT100.	
WEEK V	PLUGGING
Braking of a squirrel cage induction motor by plugging using programmable logic controller.	
WEEK VI	CONTROL OF LIFT
Control of lift using programmable logic controller.	
WEEK VII	TRAFFIC SIGNAL CONTROL
Traffic signal control using programmable logic controller.	
WEEK VIII	IMPLEMENTATION OF TIMERS
Implementation of ON - delay and OFF - delay timers using PLC.	
WEEK IX	SOLAR TRACKING
Solar tracking using programmable logic controller.	
WEEK X	DIRECT ONLINE STARTER
Direct online starter for AC motor implementation using programmable logic controller.	
WEEK XI	UP DOWN COUNTER
Implementation of up down counter to count the objects in a store using PLC.	
WEEK XII	DIGITAL CLOCK
Implementation of 24 hour digital clock using programmable logic controller.	
WEEK XIII	TIMERS
Implementation of on delay, off delay and retentive timer using programmable logic controller.	
WEEK XIV	SEQUENTIAL CONTROL
Sequential control of three motors with a time delay using programmable logic controller.	

TEXTBOOKS

1. John R. Hack Worth, Frederick D. Hack Worth, Jr., “Programmable logic controllers: programming methods and applications”, Pearson Education, 4th edition, 2008.

2. W. Bolton “Programmable logic controllers”, Newnes Elsevier , 4th edition, 2006.

REFERENCE BOOKS:

1. Luis A. Bryan, E. A. Bryan, “Programmable Controllers theory and implementation”, American technical publisher, 4th edition, 2002.

2. Frank D. Petruzella, “Programmable logic controllers”, Tata McGraw hill, 3th edition, 2010.

XVII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO’s	Reference
1	Star - delta starter.	CO 5	T1: 11.2
2	Automatic forward and reverse control	CO 5	T1: 11.1 -11.5

3	Fault annunciation system	CO 6, CO 8	T2: 13.3
4	Temperature control system	CO 6	T1:14.1
5	Plugging	CO 5	T1: 11.3
6	Control of lift	CO 8	T1: 11.1 -11.5
7	Traffic signal control	CO 7	T2: 9.1-9.4
8	Implementation of timers	CO 1	T2: 9.1-9.4
9	Solar tracking	CO 6, CO 8	T1:14.4
10	Direct online starter	CO 5	T1: 11.1
11	Up down counter	CO 2	T2:10.3
12	Digital clock	CO 3	T2:10.1-10.5
13	Timers	CO 1	T2: 9.1-9.4
14	Sequential control	CO 4	T1:14.2

XVIII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Motor Control:** Speed control of three phase induction motor
2	**Motor Control:** Speed control of DC motor
3	**Line Protecton:** Over voltage and under voltage protection
4	**Line Protecton:** Over Current Protection
5	**Reservoir control:** Water level control in a reservoir
6	**Motor Control:**Speed control of induction motor using PLC and VFD

Signature of Course Coordinator **HOD,EEE**
Mr. P Mabuhussain
Assistant Professor, EEE

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**

PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**

PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**

PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**
PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**
PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer. 1. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043
ELECTRONICS AND COMMUNICATION ENGINEERING
COURSE DESCRIPTION

<table>
<tr><td>Course Title</td><td colspan="5">MICROPROCESSORS AND MICROCONTROLLERS LABORATORY</td></tr>
<tr><td>Course Code</td><td colspan="5">AEC108</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td>VI</td><td colspan="4">ECE</td></tr>
<tr><td>Course Type</td><td>Core</td><td colspan="4"></td></tr>
<tr><td>Regulation</td><td>IARE - R16</td><td colspan="4"></td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>3</td><td>2</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Ms. B Lakshmi Prasanna, Assistant Professor</td></tr>
</table>

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEC002	III	Digital System Design

II COURSE OVERVIEW:

This laboratory course will facilitates the students to program 8086 microprocessor and 8051 microcontroller. Win862 software will be used for writing and debugging assembly language programs. The course includes performing arithmetic and logical operations, string manipulations, code conversions and interfacing of I/O devices to processor/controller. The hands-on experience acquired by the student's during the course makes them to carry out processor/controller based projects and extend their knowledge on the latest trends and technologies in the field of embedded system.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Microprocessors and Microcontrollers Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the Principal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
1	1	1	1	1	05

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
1	1	1	1	1	05

VI COURSE OBJECTIVES:

The students will try to learn:

I	Assembly language programming skills ranging from simple arithmetic operations to interfacing real time systems.
II	The usage of software tools to design, debug and test microprocessor/microcontroller based projects using assembly language programming.
III	The design of microcomputer and microcontroller based real-time applications in the fields of communication systems, home based automation systems, automobiles and unmanned applications.

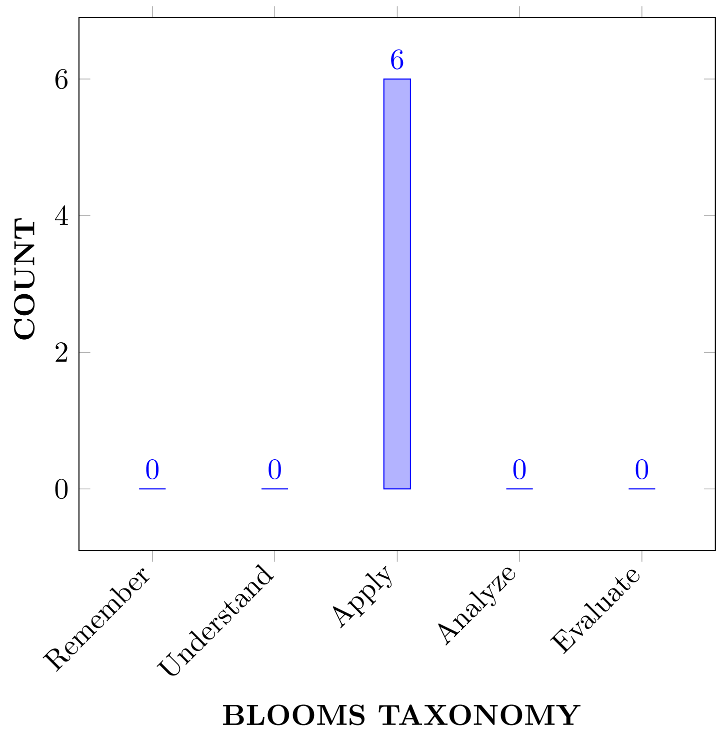
VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Make use of** emulators and assemblers for writing, compiling and running an assembly language programs on training boards.	Apply
CO 2	**Develop** Assembly language programs for accomplishing code conversions, string manipulations and sorting of numbers.	Apply
CO 3	**Choose** serial or parallel communication for transmitting the data between microprocessor or microcontroller and peripherals.	Apply

CO 4	**Utilize** Analog to Digital and Digital to Analog converters with processor or controller for data conversion.	Apply
CO 5	**Select** suitable registers of microcontroller and write assembly language program to verify timer or counter operations.	Apply
CO 6	**Build** an interface between processor or controller and peripherals to provide solutions to the real world problems.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering Knowledge:** Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems.	3	Day to Day Evaluation/ CIE/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Day to Day Evaluation/ CIE/SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	Day to Day Evaluation/ CIE/SEE

PO 5	**Modern Tool Usage:**Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	Day to Day Evaluation/ CIE/SEE
PO 9	**Individual and Teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	2	Day to Day Evaluation/ CIE/SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	Day to Day Evaluation/ CIE/SEE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Build embedded software and digital circuit development platform for robotics, embedded systems and signal processing applications.	3	Day to Day Evaluation/ CIE/SEE

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Make use of emulators and assemblers for writing, compiling and running an assembly language programs with the **knowledge of science, Engineering fundamentals, and an Engineering specialization** on training boards to the solution of complex Engineering problems.	3
	PO 2	Make use of emulators and assemblers for writing, compiling and running an assembly language programs with **information and data collection** for **developing solutions** on training boards and **interpret the results**.	3
	PO 3	**Understand customer needs** and make use of emulators and assemblers for **managing design process** and **use creativity to establish innovative solutions** by writing, compiling and running an assembly language programs on training boards	3
	PO 5	Make use of emulators and assemblers for writing, compiling and running an assembly language program on training boards using **Computer software**.	1

	PO 9	Make use of emulators and assemblers for writing, compiling and running an assembly language programs by **referring textbooks** on training boards in **hands-on labs** and **build an ability to work with all levels of people in an organization**	3
	PO 10	Make use of emulators and assemblers for writing, compiling and running an assembly language programs on training boards and **write effective reports** .	1
	PSO 1	Make use of emulators and assemblers**(embedded software)** for writing, compiling and running an assembly language programs on training boards to **build embedded system applications.**	2
CO 2	PO 1	write Assembly language programs for accomplishing code conversions, string manipulations and sorting of numbers by **applying the knowledge of mathematics, Engineering fundamentals, and an Engineering specialization** to the solution of complex Engineering problems	3
	PO 2	Understand the given **problem statement** and develop assembly language program for accomplishing sorting of numbers, code conversions and string manipulation to provide processor/controller based **solution** and **validate** the obtained **results.**	4
	PO 3	Develop **design process** for accomplishing code conversions, string manipulations and sorting of numbers and establish **innovative solutions** to meet the **requirements of user**.	3
	PO 5	Use **computer software** and write Assembly language programs for accomplishing code conversions, string manipulations and sorting of numbers to provide solutions for complex Engineering activities with an understanding of the limitations.	1
	PO 9	**Take a defined problem** and **refer appropriate textbook, use hands-on labs** and develop **the solutions** for code conversions, string manipulations and sorting of numbers.	4
	PO 10	Develop Assembly language program for accomplishing code conversions, string manipulations and sorting of numbers **and write effective reports and design documentation.**	1
	PSO	Utilize **embedded software and digital circuit platforms** perform code conversions which are commonly used in various **embedded applications**.	2
CO 3	PO 1	Perform serial or parallel communication by applying the **knowledge of mathematics, Engineering fundamentals, and an Engineering specialization** for transmitting the data between microprocessor or microcontroller and peripherals.	3

	PO 2	Understand the given data transfer schemes **(problem statement)**and interface microprocessor with serial I/O ports and develop**experimental design** to establish data transfer **(solution)** and**validate** the obtained **results.**	5
	PO 3	Develop processor or controller based systems by **managing the designing process** to establish serial/ parallel communication based on **customer needs** with appropriate consideration for **the public health and safety,**and Environmental considerations and provide the **innovative solutions**	4
	PO 5	Make use of **software and hardware tools** to perform data transfer between processor and I/O devices.	1
	PO 9	Focus on working as a **member or leader** in designing the processor based data transfer schemes in **hands-on labs** by **referring appropriate textbooks** and **evaluate their performance.**	4
	PO 10	Recognize the role of microprocessors and controllers in performing the data transfer by **communicating effectively and write effective reports.**	1
	PSO 1	Utilize **embedded software and digital circuit platforms** to perform data transfer in various **Embedded applications.**	2
CO 4	PO 1	Utilize Analog to Digital and Digital to Analog converters by the **knowledge of mathematics,Engineering fundamentals, and an Engineering specialization** with processor or controller for data conversion.	3
	PO 2	**Identify the problem** and **conduct experimental design** using Analog to Digital and Digital to Analog converters with processor or controller with **Information and data collection** for data conversion**(Solution development)** and **Interpretation of results**.	5
	PO 3	Design processor or controller based systems to perform analog to digital conversion or digital to analog conversion based on **customer needs** and use **creativity** in designing solution with appropriate consideration for the**public health and safety, and Environmental considerations.**	4
	PO 5	Utilize **software and hardware tools** to perform data conversion between processor and ADC/DAC.	1
	PO 9	Focus on working as a **member or leader** in designing the processor based data conversion techniques in **hands-on labs** by **referring appropriate textbooks** and**evaluate their performance**	4
	PO 10	Identify the role of microprocessors, ADC and DAC devices in performing the data conversion and **write effective reports.**	1
	PSO 1	Make use of **embedded software** to perform data conversion in various **embedded applications.**	2

CO 5	PO 1	Make use of suitable registers of microcontroller and write assembly language program to verify timer or counter operations **by applying the knowledge of mathematics,Engineering fundamentals, and an Engineering specialization**.	3
	PO 2	Understand the requirements **(opportunity)** of timer/counters in industrial applications**(problem statement)** and design controller based solution**(solution)** to perform given job and **validate** the obtained **results** in real time environment.	5
	PO 3	Design microcontroller based systems to perform timer/counter operations which is necessary in automated industries based on **customer needs** and use**creativity** in designing solution with appropriate consideration for the**public health and safety, and Environmental considerations**	4
	PO 5	Make use of **software and hardware tools** for effective implementation of timer/counter applications.	1
	PO 9	Work effectively as a **member or leader** in designing the controller based timer/ counter operations in **hands-on labs** by**referring appropriate textbooks** and**evaluate their performance**	4
	PO 10	Identify the role of microcontrollers in performing the timer/ counter operations by **writing effective reports.**	1
	PSO 1	Utilize **embedded software and digital circuit platforms** to build **robotic applications** where timer/counter operations are required.	2
CO 6	PO 1	Develop an interface between processor or controller and peripherals by applying **the knowledge of mathematics,Engineering fundamentals, and an Engineering specialization** to provide solutions to the real world problems.	3
	PO 2	Understand the requirements **(opportunity)** of industrial applications **(problem statement)** and design processor or controller based solution **(solution)** to perform given job and **validate** the obtained**results** in real time environment.	5
	PO 3	Develop processor or controller based systems by **managing the designing process** to establish **innovative solutions** based on**customer needs** with appropriate consideration for **the public health and safety,** and Environmental considerations.	4
	PO 5	Make use of **software and hardware tools** for effective design of processor or controller based applications.	1
	PO 9	Focus on working as a **member or leader** in designing the processor and controller based solutions in**hands-on labs** by **referring appropriate textbooks** and**evaluate their performance**	4

	PO 10	Recognize the role microprocessors and controllers in providing the solutions to real-time systems by **writing effective reports.**	1
	PSO 1	Utilize **embedded software and digital circuit platforms** to create processor or controller based solutions in **Embedded applications**.	2

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES						PSO'S
	PO 1	PO 2	PO 3	PO 5	PO 9	PO 10	PSO 1
CO 1	3	3	3	1	3	1	2
CO 2	3	4	3	1	4	1	2
CO 3	3	5	4	1	4	1	2
CO 4	3	5	4	1	4	1	2
CO 5	3	5	4	1	4	1	2
CO 6	3	5	4	1	4	1	2

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**DESIGN A PROGRAM USING WIN862**
	Design and develop an Assembly language program using 8086 microprocessor and to show the following aspects. (a)Programming (b)Execution (c)Debugging To Demonstrate the win 862 software and Trainer kit for 8086 Microprocessor
WEEK II	**16 BIT ARITHMETIC AND LOGICAL OPERATIONS**
	Write an ALP program to perform 16 Bit arithmetic and logical operations using WIN862 software
WEEK III	**MULTIBYTE ADDITION AND SUBTRACTION**
	(a) Write an ALP program to perform multi byte addition and subtraction (b) Write an ALP program to perform 3*3 matrix multiplication and addition

WEEK IV	**PROGRAMS TO SORT NUMBERS**
	(a)Write an ALP program to perform ascending order using 8086 (b)Write an ALP program to perform descending order using 8086
WEEK V	**PROGRAMS FOR STRING MANIPULATIONS OPERATIONS**
	(a)Write an ALP program to insert or delete a byte in the given string (b)Write an ALP program to search a number/character in a given string (c)Write an ALP program to move a block of data from one memory location to the other (d)Write an ALP program for reverse of a given string.
WEEK VI	**CODE CONVERSIONS**
	(a) Write an ALP program to convert packed BCD to Unpacked BCD (b) Write an ALP program to convert packed BCD to ASCII (c) Write an ALP program to convert hexadecimal to ASCII
WEEK VII	**INTERFACING STEPPER MOTOR**
	(a) Write an ALP program to rotate stepper motor in clockwise direction (b) Write an ALP program to rotate stepper motor in anti clockwise directio
WEEK VIII	**INTERFACING ADC and DAC DEVICES**
	(a) Write an ALP program to convert analog to digital using 8086 (b) Write an ALP program to convert digital to analog using 8086
WEEK IX	**INTERFACING KEYBOARD TO 8086**
	Write an ALP program to interface keyboard to 8086
WEEK X	**SERIAL AND PARALLEL COMMUNICATION**
	(a) Parallel communication between two microprocessors using 8255 (b) Serial communication between two microprocessor kits using 8251
WEEK XI	**INTERFACING TRAFFIC LIGHT CONTROLLER AND TONE GENERATOR**
	(a) Write a program to interface traffic light controller (b) Write an ALP program to interface tone generator
WEEK XII	**ARITHMETIC AND LOGICAL OPERATIONS USING 8051**
	Write an ALP program to perform 16 Bit arithmetic and logical operations using 8051 microcontroller
WEEK XIII	**TIMER/COUNTER**
	Write an ALP Program and verify Timer/Counter using 8051
WEEK XIV	**INTERFACING KEYBOARD TO 8051**
	Write an ALP program to interface keyboard to 8051

TEXTBOOKS

1. Ray A.K, Bhurchandi K.M, "Advanced Microprocessor and Peripherals", TMH, 2nd Edition, 2012
2. Muhammad Ali Mazidi, J.G. Mazidi, R.D McKinlay," The 8051 Microcontroller and Embedded systems using Assembly and C", Pearson education, 2nd Edition, 2009.
3. Douglas V. Hall, "Microprocessors and Interfacing Programming and Hardware", TMGH, 2nd Edition, 1994.

REFERENCE BOOKS:

1. Kenneth J. Ayala, “The 8051 Microcontroller”, Thomson Learning, 3rd edition, 2005.
2. Manish K. Patel, “The 8051 Microcontroller Based Embedded Systems”, McGraw Hill, 1st Edition, 2014.
3. Ajay V Deshmukh, ”Microcontrollers”, TATA McGraw Hill publications, 2nd Edition, 2012.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO’s	Reference
1	Design a program using WIN862	CO 1/ CO 2	T1: 3.3
2	16 bit arithmetic and logical operations	CO1/ CO2	T1: 3.4
3	Multibyte addition and subraction	CO1/ CO2	T1: 3.4
4	Programs to sort numbers	CO1/ CO2	T1: 3.4
5	Programs for string manipulations operations	CO1/ CO2/ CO3	T1: 3.4
6	Code conversions.	CO1/ CO2	T1: 3.4
7	Interfacing stepper motor to 8086 microprocessor	CO1/ CO6	T1: 5.8
8	Interfacing ADC and DAC devices	CO1/ CO4/ CO6	T1: 5.6, 5.7
9	Interfacing keyboard to 8086 microprocessor	CO1/ CO6	T1: 6.3
10	Serial and Parallel communication	CO1/ CO3/ CO6	T1: 6.4
11	Interfacing traffic light controller and tone Generator to 8086 microprocessor	CO1/ CO6	T1: 6.5, 6.6
12	Arithmetic and logical operations using 8051 microcontroller	CO1/ CO2	R1: 4,5
13	Timer/Counter operations	CO1/ CO5/ CO6	R1: 2
14	Interfacing keyboard to 8051 microcontroller	CO1/ CO6	R1: 8

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Write an Assembly Language Program to rotate a 200 teeth, 4 phase stepper motor with 5 rotations clockwise and then 5 rotations anticlockwise, Rotate through angle 135o in 2 sec, rotate the shaft at a speed of 10 rotations per minute.
2	Develop an Assembly Language program to interface 8251 with 8086 at an address 80H, initialize it in asynchronous transmit mode, with 7 bits character size, baud factor 16, one start bit and 1 stop bit, even parity enabled and then transmit a message "HAPPY NEW YEAR" in ASCII form to a modem.
3	Interface ADC 0808 with 8086 using 8255 ports. Use Port A of 8255 for transferring digital data output of ADC to the CPU and Port C for control signals. Assume that an analog input is present at I/P2 of the ADC and a clock input of suitable frequency is available for ADC. Draw the schematic and timing diagram of different signals of ADC0808.
4	Interface 12-bit DAC with 8086 and develop the Assembly Language program to generate the step waveform of duration 1sec, maximum voltage 3 volts and determine the duration of each step.
5	Write a program to initialize 8251 in synchronous mode with even parity, single SYNCH character, 7-bit data character. Then receive FFH bytes of data from a remote terminal and store it in the memory at address 5000H: 2000H.
6	A switch is connected to pin P1.2. Write an 8051 Assembly Language program to monitor SW and create the following frequencies on pin P1.7. SW=0: 500Hz, SW=1: 750Hz, use Timer 0, mode 1 for both of them.
7	Write an Assembly Language program for 8051 Microcontroller to count number of interrupts arriving on external interrupt pin INT1. Stop when counter overflows and disable the interrupt. Give the indication on pin P0.0

Signature of Course Coordinator **HOD,ECE**
Ms. B Lakshmi Prasanna, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRONICS ENGINEERING
COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Power Systems Protection**				
Course Code	AEE014				
Program	B.Tech				
Semester	VI				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. T. Mahesh, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE004	III	DC Machines and Transformers
B.Tech	AEE007	IV	AC Machines

II COURSE OVERVIEW:

The main objective of the course is to provide an overview of the principles and schemes for protecting power lines, transformers, buses, generators. It provides in depth knowledge of various types of relays and circuit breakers. It includes protection against over voltages in power system using lighting arrestors and insulation co-ordination.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
UTILIZATION OF ELECTRICAL POWER	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
70 %	Understand
20 %	Apply
0 %	Analyze

VI COURSE OBJECTIVES:

The students will try to learn:

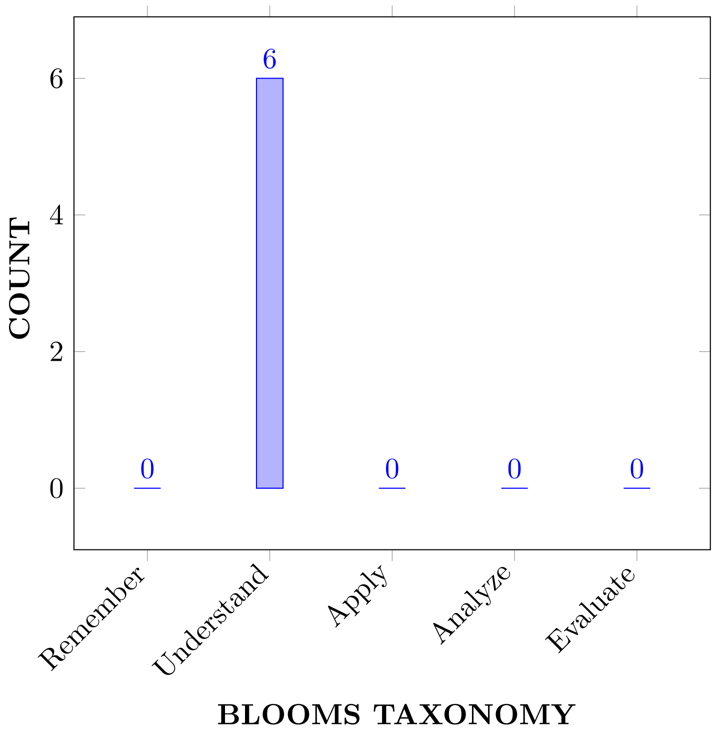
I	Theory, construction, applications of types circuit breakers, Relays for protection of generators, transformers and protection of feeders from over- voltages and other hazards.
II	Applications of the main components used in power system protection for electric machines, transformers, bus bars, overhead and underground feeders.
III	The skills to design the feasible protection systems needed for each main part of a power system.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Describe** types of existing circuit breakers, their design and constructional details used for the protection of power system under different mal condition.	Understand
CO 2	**Explain** construction and working of various types relays for detection of fault and disconnection of a faulty section.	Understand
CO 3	**Classify** substations based on operating voltages and their circuit elements helps in provide reliable supply for the consumers.	Understand
CO 4	**Summarize** protection schemes of feeder and bus-bars that plays an effective role in protection of transmission lines.	Understand
CO 5	**Outline** protection schemes of generator and transformer against open and short circuit faults for maintaining continuous supply.	Understand
CO 6	**Classify** types of lightening arrestors for the protection of power system network from over voltages in order to provide uninterruptable power supply.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/CIE/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	SEE/CIE/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	SEE/CIE/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	SEE /CIE/AAT
PO 5	Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	SEE/CIE/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	3	-
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	-	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	-	✓	-	-	-	-	-	-		-	-	-
CO 5	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	✓	-	-	-	-	-	-	-	-		-	-	-

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies.
CO 1	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** to classify various Learning Process: Error Correction Learning, Memory Based Learning, Hebbian Learning, Competitive, Boltzmann Learning	3
	PO 2	**Identify the problem statement** Single Layer Perceptron: Adaptive Filtering Problem, Unconstrained Organization Techniques, Linear Least Square Filters, Least Mean Square Algorithm	2
CO 2	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** and derive the Back Propagation Learning and Accelerated Convergence formulae	3

	PO 2	Analyze the performance parameters of Back Propagation Algorithm XOR Problem, Heuristics, Output, Representation and Decision Rule, Computer Experiment, Feature Detection **first principles of Mathematics and engineering sciences.**	2
CO 3	PO 1	Identify various learning Rate Annealing Techniques, Perceptron: convergence theorem **using principles of mathematics, science, and engineering fundamentals.**	3
CO 4	PO 1	Apply the knowledge of different for techniques (**scientific Principles and mathematical principles**) for Hessian Matrix, Generalization, Cross Validation and describe different performance parameters.	3
	PO 2	Determine the parameters and Network Pruning Techniques **using first principles and Mathematics and Engineering sciences.**	2
	PO 5	Illustrate Neuro Dynamical Models, Manipulation of Attractors as a Recurrent Network Paradigm Hopfield Models to **solve complex engineering problems.**	1
CO 5	PO 1	Understand the advantages of Bayes Classifier for a Gaussian Environment and Multilayer Perceptron **using the fundamentals of engineering and mathematical equations**	3
CO 6	PO 1	Analyze Recurrent Network Paradigm Hopfield Models **using fundamentals of science &and engineering fundamentals.**	3
	PO 2	Categorize the Adaptive Patter in **complex engineering problems.**	3
	PO 3	Investigate and define a problem and identify Learning Vector Quantization including **environmental and sustainability limitations, health and safety and risk assessment issues**	2

Note: For Key Attributes refer **Annexure - I**

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	Program Outcomes/ No. of Key Competencies Matched												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	1	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	-	1	-	-	-	-	-	-		-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	1	2	-	-	-	-	-	-	-	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	80	-	-	80	-	-	-	-	-	-		-	-	-
CO 5	100		-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	70	60	-	-	-	-	-	-	-	-		-	-	-

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C $\leq$ 5% – No correlation

2 - 40 % $<$C $<$ 60% –Moderate

1-5 $<$C$\leq$ 40% – Low/ Slight

3 - 60% $\leq$ C $<$ 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	3		-	3	-	-	-	-	-	-		-	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	3	2	-	-	-	-	-	-	-	-		-	-	-
TOTAL	18	10	2	-	3	-	-	-	-	-	-	-	-	-	-
AVERAGE	3	3	2	-	3		-	-	-	-	-	-	- -	-	-

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Quiz	✓	Tech - Talk	-	Certification	-
Term Paper	-	Seminars	-	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	✓	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
✓	Assessment of Mini Projects by Experts		

XVIII SYLLABUS:

MODULE I	**CIRCUIT BREAKERS**
	Circuit Breakers: Elementary principles of arc interruption, restriking and recovery voltages, restriking phenomenon, average, maximum and rate of rise of restriking voltage, current chopping and resistance switching, circuit breaker ratings and specifications, auto reclosures, description and operation of various types of circuit breakers, minimum oil circuit breakers, air blast circuit breakers, vacuum and SF6 circuit breakers, numerical problems.
MODULE II	**ELECTROMAGNETIC, STATIC AND NUMERICAL RELAYS**
	Electromagnetic relays: Principle of operation and construction of attracted armature, balanced beam, induction disc and induction cup relays; Relays classification: instantaneous, definite minimum time and inverse definite minimum time relays over current / under voltage relays, direction relays, differential relays and percentage differential relays, universal torque equation; Distance relays: Impedance, reactance, mho and offset mho relays, characteristics of distance relays; Static relays: Overview of static relay, block diagram, operating principle and comparison, static relays versus electromagnetic relays; Numerical relays: Introduction, block diagram of numerical relay, sampling theorem, anti-aliasing filter, block diagram of phasor measurement unit and intelligent electronic device, data acquisition systems and numerical relaying algorithms, applications and numerical problems.
MODULE III	**SUBSTATIONS AND PROTECTION OF FEEDER / BUS BAR**

	Indoor and outdoor substations: Substations layout, bus bar arrangements like single, sectionalized, main and transfer bus bar system with relevant diagrams; Gas insulated substation (GIS): Types, single line diagram, constructional aspects of GIS, Installation, maintenance, advantages, comparison of GIS with air insulated substations. Indoor and outdoor substations: Substations layout, bus bar arrangements like single, sectionalized, main and transfer bus bar system with relevant diagrams; Gas insulated substation (GIS): Types, single line diagram, constructional aspects of GIS, Installation, maintenance, advantages, comparison of GIS with air insulated substations.
MODULE IV	**GENERATOR AND TRANSFORMER PROTECTION**
	Generator protection: Protection of generators against stator faults, rotor faults, and abnormal conditions, restricted earth fault and inter turn fault protection, numerical problems on percentage winding unprotected; Transformer protection: Percentage differential protections, numerical problem on design of current transformers ratio, buchholz protection.
MODULE V	**PROTECTION AGAINST OVER VOLTAGES**
	Neuro Dynamics: Dynamical Systems, Stability of Equilibrium States, Attractors, Neuro Dynamical Models, Manipulation of Attractors as a Recurrent Network Paradigm Hopfield Models – Hopfield Models, Computer Experiment

TEXTBOOKS

1. Sunil S Rao, "Switchgear and Protection", Khanna Publishers, 1st Edition, 2013.

REFERENCE BOOKS:

1. Paithankar, S R Bhide, "Fundamentals of Power System Protection", PHI, 1st Edition, 2003.
2. C LWadhwa, "Electrical Power Systems", New Age international (P) Limited, 6th Edition, 2010.
3. VK Mehta," Principles of power systems", S Chand Publications, 4th Edition, 2009.

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
1-2	Understand the Elementary principles of arc interruption	CO 1, CO 2	T2: T2: 1.1 R2: 1.1
3-4	Understand the concept restriking and recovery voltages, restriking phenomenon, average, maximum and rate of rise of restriking voltage	CO 2	T2: 4.1 R2: 1.6
5-6	Analyze average, maximum and rate of rise of restriking voltage with examples	CO 2	T2: 4.2 R2: 1.6
7-8	Explain concept of the current chopping.	CO 2	T2: 5.1 R2: 1.7

9-10	Understand the concept of resistance switching	CO 2	T2: 5.3 R2: 1.7 3
11-12	Understand the operation of various types of circuit breakers such as minimum oil circuit breakers.	CO 3	T2: 5.5 R2: 1.7
13-14	Explain the concept of vacuum.	CO 3	T2: 4.5 R2: 1.7.1
15-16	Explain the concept of SF6 circuit breaker.	CO 3	T2: 4.12 R2: 1.15
17-18	Analyze examples on recovery, rate of rise of restriking voltage	CO 2	T2: 4.9 R2: 1.8
19-20	Understand the Principle of operation and construction of attracted armature.	CO 4	T2: 4.9 R2: 1.10
21-22	Explain the operation of balanced beam.	CO 3	R2: 2.7
23-24	Explain the operation induction disc.	CO 1	T2: 2.3 R2: 1.4
25-26	List out types of relays and discuss briefly on instantaneous, definite minimum time and inverse relay	CO 1	T2: 4.6 R2: 1.4
27-28	Understand the concept of definite minimum time relays	CO 4	T2: 6.1 R2: 5.1
29-30	Understand the concept over current / under voltage relays.	CO 4	T2:6.1.1
31-32	Explain the working of direction relays.	CO 4	T2: 6.1.2 R2: 5.1.2
33-34	Explain the working of differential relays	CO 4	T2: 6.1.2 R2: 5.1.2
35-36	Explain the working of percentage differential relays.	CO 4	T2: 6.3.1 R2: 5.2
37-40	Derive universal torque equation; and discuss briefly on distance relay.	CO 4	T2: 6.3.2 R2: 5.4
41-42	Explain operation and characteristics of Impedance relay	CO 4	T2: 6.3.2 R2: 5.4
43-46	Explain operation and characteristics reactance relay.	CO 4	T2: 6.7.1 R2:5.5

Signature of Course Coordinator **HOD,EEE**
Mr. T. Mahesh, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions	**10**

	5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**

PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project.	**12**

	6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	
PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Power System Operation and Control**				
Course Code	AEE016				
Program	B.Tech				
Semester	VII				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Dr. P. Sridhar, Professor				

I COURSE OVERVIEW:

This course deals with the concept of power system management to meet load demand at optimal operating cost and various ways in controlling electrical power generation of Thermal and Hydrothermal plants and modeling of electrical and hydraulic. This course also gives the knowledge of Load Frequency Control in multi areas and classification of Loads and its Compensation. This course address the various real time issues like Power Factor and its improvement.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE012	VI	Power System Analysis

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Power System Operation and Control	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	✓	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
20%	Understand
60%	Apply
20%	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc.

VI COURSE OBJECTIVES:

The students will try to learn:

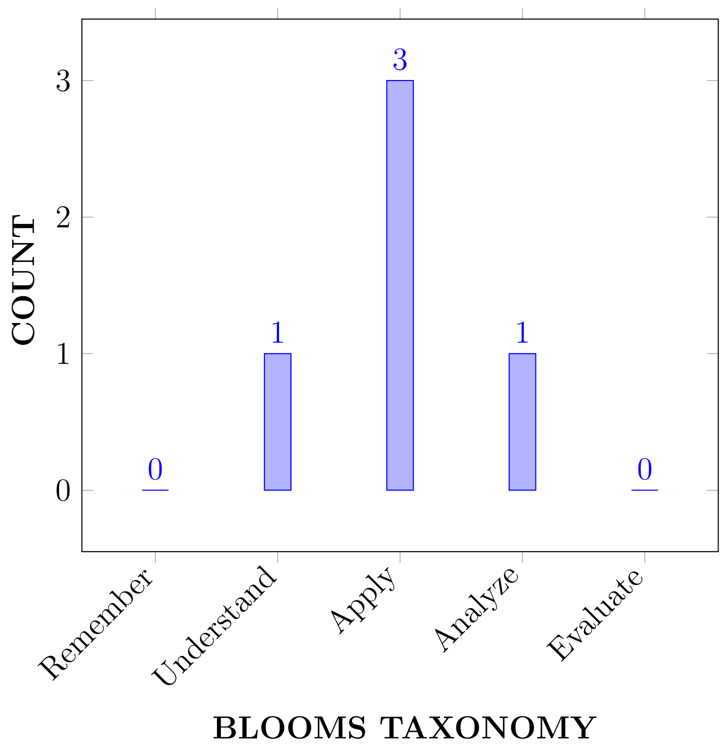
I	Demonstrate economic operation of power systems, hydrothermal scheduling.
II	Illustrate modeling of turbines, generators and automatic controllers.
III	Discuss single area and two area load frequency control.
IV	Analyze reactive power control and load modeling.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Solve** the optimum load scheduling with various constraints in Thermal and Hydro power Stations using conventional optimization techniques and general transmission line loss formula.	Apply
CO 2	**Develop** the mathematical models of the mechanical and electrical components in the power generation for deriving the transfer function of the power system.	Apply
CO 3	**Distinguish** single area and two area load frequency control for minimizing the transient and steady state deviations using various controllers.	Analyze
CO 4	**Choose** different types of compensating equipment for controlling voltage, reactive power and power factor for improving the reliability in compensated and uncompensated transmission lines.	Apply
CO 5	**Interpret** the types of loads in the power systems from their characteristic factors.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem Analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The Engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	AAT/CIE/SEE
PO 2	**Problem Analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	AAT/CIE/SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	AAT/CIE/SEE
PO4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	AAT/CIE/SEE
PO 6	**The Engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	AAT/CIE/SEE
PO 7	**Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	1	AAT/CIE/SEE
PO 9	**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	1	AAT/CIE/SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	AAT/CIE/SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	AAT/CIE/SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, develop fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.	2	AAT/CIE/SEE
PSO 2	Focus on the components of electrical drives with its converter topologies, for energy conversion, management and auditing in specific applications of industry and sustainable rural development.	1	AAT/CIE/SEE

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO(s)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	✓	✓	-	✓	✓	-	✓	✓	-	✓	✓	✓	-
CO 2	✓	✓	✓	-	-	✓	-	-	✓	✓	-	✓	✓	-	-
CO 3	✓	✓	✓	✓	-	✓	✓	-	✓	✓	-	✓	✓	-	-
CO 4	✓	✓	✓	✓	-	✓	✓	-	✓	✓	-	✓	-	✓	-
CO 5	✓	✓	✓	-	-	✓	-	-	✓	✓	-	✓	-	✓	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO(s) PSO(s)	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Recollect** (knowledge) the basic concept of generation of electricity from Thermal and Hydrothermal power stations and (understand) the importance fundamentals of optimal operation of Generating plants by applying the principles of **mathematics and science**.	3
	PO 2	**Identify** the optimum problem and analyse heat rate curve, cost curve, incremental fuel and production costs, input-output characteristic **using the first principles of mathematics and engineering sciences**.	6
	PO 3	**Design** the solution for optimal operation of the power system to meet the specified needs with appropriate consideration **for societal and environmental considerations**.	2
	PO 4	**Analyze** and interpret the data of optimal scheduling of thermal and hydro power stations obtained by various research methods and knowledge to conduct **investigation of complex problems**.	2

Course Outcomes	PO(s) PSO(s)	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 6	**Apply** the knowledge of optimal scheduling of power stations for assessment of societial and safety issues **with responsibilities relevant to the professional engineering practice**.	2
	PO 7	**Understand** the need for optimal operation and Unit Commitment of power generating systems to reduce the impact of oxides of carbon, sulphur and nitrogen **on the environment** .	2
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance of optimal scheduling of power stations	2
	PO 10	**Communicate** effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation based on optimal scheduling problems in power generation plants.	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of efficient power generation scheduling.	2
	PSO 1	**Develop**(understand) the optimal scheduling of thermal and hydro power stations **involving power generation**.	4
	PSO 2	**Understands** the Unit Commitment **and** conventional optimization techniques by **focus on the components of system in specific applications of industry and academia**	2
CO 2	PO 1	**Recall** the knowledge on the various Components in generating plants **engineering fundamentals**.	3
	PO 2	**Describe** the mechanical and electrical components involved in the operation of power systems using the **first principles of mathematics and engineering sciences**.	6
	PO 3	**Design** the mathematical models of the mechanical and electrical components and develop the **solutions for complex Engineering**.	2
	PO 6	**Apply** the knowledge of optimal operation of generators in power stations for assessment of societial and safety issues **with responsibilities relevant to the professional engineering practice**.	2
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance of optimal design of power generation components	2

Course Outcomes	PO(s) PSO(s)	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 10	**Communicate** effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation based on mathematical modelling of power generation plant components.	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of efficient power generation components designing.	2
	PSO 1	**Develop** the mathematical models of the mechanical and electrical components in operation of power systems **to derive the transfer function of systems involved in power generation**.	1
CO 3	PO 1	**Understand** the modeling of excitation systems system **knowledge of engineering fundamentals related to electrical machines**.	2
	PO 2	**Describe** the fundamental characteristics of an excitation system **using the first principles of mathematics and engineering sciences**.	2
	PO 3	**Design** the mathematical models of the mechanical and electrical components and develop the **solutions using complex Engineering**.	3
	PO 4	**Analyze** the mathematical models of the mechanical and electrical components and develop the **solutions using complex Engineering**.	3
	PO 6	**Apply** the knowledge of load frequency control in power systems for assessment of societial and safety issues **with responsibilities relevant to the professional engineering practice**.	2
	PO 7	**Understand** the need for load frequency control in power systems to reduce the impact of oxides of carbon, sulphur and nitrogen produced during power generation **on the environment** .	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance of load frequency control in power systems	3
	PO 10	**Communicate** effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation based on load frequency control in single and two area system.	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of efficient frequency control strategies.	3

Course Outcomes	**PO(s) PSO(s)**	**Justification for mapping (Students will be able to)**	**No. of Key competencies matched.**
	PSO 1	**Design** the load frequency control for single area and two area **to minimize deviations and errors involving power transmission and distribution**.	4
CO 4	PO 1	Understanding the concepts of voltage, powerfactor and reactive power control in the power systems using **basic fundamentals of mathematics, electrical engineering**.	2
	PO 2	**Analyze** the importance of controlling voltage and reactive power for stable operation of the power system **using first principles of science and mathematics**	7
	PO 3	Design the compensating equipment for control of voltage and reactive power problem and develop **solutions using complex Engineering**.	2
	PO 4	**Analyze** the need for reactive power in the power system and associated problems on power delivery and develop the **solutions using complex Engineering**.	2
	PO 6	**Apply** the knowledge of reactive power control in power systems for assessment of societial and safety issues **with responsibilities relevant to the professional engineering practice**.	2
	PO 7	**Understand** the effect of reactive power control and powerfactor control in power systems to reduce the impact of oxides of carbon, sulphur and nitrogen produced during power generation **on the environment** .	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance of control of reactive power and power factor in power systems	2
	PO 10	**Communicate** effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation based on reactive power control and power factor control.	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of quality of the power.	2
	PSO 2	**Identify** various reactive power compensating equipment and topologies **for specific applications of industry and energy management**	2
CO 5	PO 1	**Illustrate** different types of loads and their characteristics using the **knowledge of Electrical Engineering fundamentals**	2
	PO 2	**Analyze** the voltage drop and power loss in a distribution system using the **solutions for complex engineering problems**.	5
	PO 3	**Design** various methods for load compensation and develop the **solutions for complex Engineering**.	3

Course Outcomes	PO(s) PSO(s)	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 6	**Apply** the knowledge of load compensation in power stations for assessment of societial and safety issues **with responsibilities relevant to the professional engineering practice**.	2
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance of load compensation in power generation.	2
	PO 10	**Communicate** effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation based on load compensation and different types of loads.	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of efficient load compensation.	2
	PSO 2	**Identify** various reactive power load compensating mathods and topologies **for specific applications of industry and energy management**	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO(s)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	6	2	2	-	2	2	-	2	1	-	2	4	2	-
CO 2	3	6	2	-	-	2	-	-	2	1	-	2	1	-	-
CO 3	2	2	3	3	-	2	1	-	3	1	-	3	4	-	-
CO 4	2	7	2	2	-	2	1	-	2	1	-	2	-	2	-
CO 5	2	5	3	-	-	2	-	-	2	1	-	2	-	2	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO(s)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	60	20	18.2	-	40	66.7	-	16.7	20	-	25	80	18.2	-
CO 2	100	60	20	-	-	40	-	-	16.7	20	-	25	20	-	-
CO 3	66.7	20	30	27.3	-	40	33.3	-	25	20	-	37.5	80	-	-
CO 4	66.7	70	20	18.2	-	40	33.3	-	16.7	20	-	25	-	18.2	-
CO 5	66.7	50	30	-	-	40	-	-	16.7	20	-	25	-	18.2	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - 40 % <C < 60% –Moderate
3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO(s)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	1	1	-	2	2	-	1	1	-	1	3	1	-
CO 2	3	3	1	-	-	2	-	-	1	1	-	1	1	-	-
CO 3	3	1	1	1	-	2	1	-	1	1	-	1	3	-	-
CO 4	3	3	1	1	-	2	1	-	1	1	-	1	-	1	-
CO 5	3	2	1	-	-	2	-	-	1	1	-	1	-	1	-
TOTAL	15	12	5	3	-	10	4	-	5	5	-	5	7	3	-
AVERAGE	3	2.4	1	1		2	1.3		1	1		1	2.3	1	

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Quiz	✓	Tech - Talk	-	Certification	-
Term Paper	-	Seminars	✓	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	✓	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
✓	Assessment of activities/ Modeling & Experimental Tools in Engineering by Experts		

XVIII SYLLABUS:

UNIT I	**ECONOMIC OPERATION OF POWER SYSTEMS**
	Optimal scheduling of thermal power system: Optimal operation of generators in thermal power stations, heat rate curve, cost curve, incremental fuel and production costs, input output characteristics, optimum generation allocation without and with transmission line losses coefficients, general transmission line loss formula, unit commitment; Optimal scheduling of hydrothermal system: Hydroelectric power plant models, scheduling problems, short term hydro thermal scheduling problem.
UNIT II	**MODELING OF GOVERNOR, TURBINE AND EXCITATION SYSTEMS**
	Modeling of governor: Mathematical modeling of speed governing system, derivation of small signal transfer function; Modeling of turbine: First order turbine model, block diagram representation of steam turbines and approximate linear models; Modeling of excitation system: Fundamental characteristics of an excitation system, transfer function, block diagram representation of IEEE type-1 model.
UNIT III	**SINGLE AREA AND TWO AREA LOAD FREQUENCY CONTROL**

	Load frequency control of single area system: Necessity of keeping frequency constant, definitions of control area, single area control, block diagram representation of an isolated power system, steady state analysis, dynamic response, uncontrolled case. Load frequency control of two area system: Uncontrolled case and controlled case, tie line bias control; Load frequency controllers: Proportional plus integral control of single area and its block diagram representation, steady state response, load frequency control and economic dispatch.
UNIT IV	**COMPENSATION FOR POWER FACTOR IMPROVEMENT AND REACTIVE POWER CONTROL**
	Voltage control: Equipment for voltage control, effect of series capacitors, line drop compensation, effect of AVR, power factor control using different types of power capacitors, shunt and series capacitors, effect of shunt capacitors (fixed and switched), power factor correction, capacitor allocation, economic justification, procedure to determine the best capacitor location; Reactive power control: Reactive power compensation in transmission systems, advantages and disadvantages of different types of compensating equipment for transmission systems; Uncompensated and compensated transmission lines: Shunt and series compensation.
UNIT V	**LOAD COMPENSATION**
	Load Compensation: characteristics of loads, factors associated with loads, relation between the load factor and loss factor; specifications of load compensator; Classification of loads: Residential, commercial, agricultural and industrial and their characteristics.

TEXTBOOKS

1. Sivanagaraju, S., et al.,Power system operation and control, Pearson Education India, 2009

2. Turan Gonen, Electric Power Distribution system, Engineering, McGraw-hill Book Company, 2007

3. Timothy J. E. Miller, Reactive power control in Electrical systems, Wiley-Interscience Publication, 1982

4. V K Mehta & Rohit Mehta, Principles of Power System, S Chand, 2015.

REFERENCE BOOKS:

1. Singh S. N., Electric Power Generation, Transmission and Distribution, Prentice Hall of India Pvt. Ltd., New Delhi, Second Edition, 2002.

2. Turan Gonen, Electrical Power Distribution System Engineering, CRC Press, Third Edition, 2014.

3. Kamaraju V., Electrical Power Distribution Systems, TMH, Publication, Edition, 2009.

4. Elgerd O. I., Electrical Energy Systems Theory, Tata McGraw-Hill, Second Edition, 2007.

WEB REFERENCES:

1. https://nptel.ac.in/courses/108/104/108104052/

2. https://nptel.ac.in/courses/108/101/108101040/

COURSE WEB PAGE:

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO(s)	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	-
CONTENT DELIVERY (THEORY)			
1	Introduction to power system operations and control	CO 1	T1:5-6
2	Optimal scheduling of thermal power system	CO 1	T1: 25-26
3	Characteristic Curves (heat rate curve, cost curve, Incremental fuel and production costs)	CO 1	T1: 26-28
4	Input-Output characteristics and Optimum generation allocation without transmission line losses coefficients	CO 1	T1: 26-28
5	Optimum generation allocation with transmission line losses coefficients	CO 1	T1: 26-28
6	General transmission line loss formula and Unit commitment.	CO 1	T1: 30-32
7	Hydroelectric power plant models	CO 1	T1: 30-32
8	Short term hydro thermal scheduling problem.	CO 1	T1: 30-32
9	Mathematical modeling of speed governing system	CO 2	T3:312-318
10	Derivation of small signal transfer function	CO 2	T3:312-318
11	Modeling of steam turbine	CO 2	T3:312-318
12	Block diagram representation of steam turbines	CO 2	T3:312-318
13	First order turbine model	CO 2	T3:312-318
14	Modeling of excitation system	CO 2	T3:322-326
15	Fundamental characteristics of an excitation system and Transfer function.	CO 2	T3:319
16	Block diagram representation of IEEE type-1 model.	CO 2	T2:11.5 R2:17.5
17	Load frequency control of single area system	CO 3	T1:84-85
18	Necessity of keeping frequency constant and Definitions of control areas (Single area & Two-area)	CO 3	T1:327-330
19	Block diagram representation of an isolated power system.	CO 3	T1:327-330
20	Steady-State and Dynamic response Analysis for uncontrolled case.	CO 3	T1:327-330

21	Load frequency control of two area system controlled and uncontrolled case	CO 3	T1:327-330
22	Load frequency control of a two area system: tie line bias control	CO 3	T1:58-59
23	Proportional plus integral control of single area control	CO 3	T1:58-59
24	Two area control block diagram representation	CO 3	T1 :60-62
25	Steady-state response in a two area system	CO 3	T1 :63-64
26	Load frequency control in a two area system	CO 3	T1 :65-68
27	Economic Dispatch	CO 4	T1:296
28	Equipment for voltage control	CO 4	T2:383 – 385
29	Impact of series capacitors and Automatic Voltage Regulators	CO 4	T2:383 – 385
30	Power factor control using different types of power capacitors (shunt and series capacitors)	CO 4	T2:383
31	Impact of switched and fixed shunt capacitors	CO 4	T1: 330-345
32	Power factor correction	CO 4	T2:337
33	Optimum location of capacitor and economic justification	CO 4	T2:342-345
34	Reactive power control	CO 4	T2:342-345
35	Different types of compensating equipment for transmission systems	CO 4	T2:337
36	Difference between compensated and uncompensated transmission lines.	CO 4	T2:325-327
37	Shunt and series reactive power compensation	CO 4	T2:325-327
38	Load Compensation	CO 5	T2:325-327
39	Characteristics of loads and factors associated with loads	CO 5	T2:25
40	Load factor and Loss factor, Classification of loads and their characteristics.	CO 5	T2:26-28
PROBLEM SOLVING/ CASE STUDIES			
41	Problems on incremental fuel cost and production cost.	CO 1	T1: 52-83
42	Problems on load sharing between the units based on governor droop characteristics	CO 1	T1: 282-286
43	Problems on optimum generation allocation with transmission line loss coefficients	CO 1	T1: 52-83
44	Problems on optimum generation allocation without transmission line loss coefficients	CO 1	T1: 108-135
45	Problems on transmission loss formula in terms of B-coefficients	CO 1	T1: 124-135
46	Mathematical models of turbine, generator and governing system	CO 2	T1: 310-313
47	Problems on single area and two area control	CO 3	T1: 346-358

48	Problems on change in generation levels of the units.	CO 4	T1: 346-358
49	Problems on change in steady state frequency and line losses in single area system	CO 4	T1: 282-286
50	Problems on deviation in frequency of the units.	CO 4	T1: 282-286
51	Problems on change in steady state frequency and line losses in two-area system	CO 4	T1: 346-358
52	Problems based on power factor improvement	CO 4	T1:405-414
53	Problems on defining the most economical power factor	CO 4	T1:405-414
54	Problems on the requirement of the capacitor ratings for power factor correction	CO 5	T1:405-414
55	Problems on annual power losses in the distribution systems	CO 5	T1:435-438
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Definitions on optimal scheduling of power plants	CO 1	T1-26 to 28
57	Definitions on mathematical modeling	CO 2	T3-321 to 318
58	Definitions on load frequency control	CO 3	T1-327 to 330
59	Definitions on voltage and reactive power control	CO 4	T2-342 to 345
60	Definitions on load compensation	CO 5	T2-206 to 208
DISCUSSION OF QUESTION BANK			
61	Economic operation of power systems	CO 1	R4:2.1
62	Modeling of governor, turbine and excitation systems	CO 2	T4:7.3
63	Economic operation of power systems	CO 3	R4:5.1
64	Compensation for power factor improvement and reactive power control	CO 4	T1:7.5
65	Load compensation	CO 5	T1: 4.1

Course Coordinator **HOD,EEE**
Dr. P.Sridhar, Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF(s)
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences **(Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations **(Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions	**10**

	5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**

PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project.	**12**

	6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	
PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**

PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer. 1. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**High Voltage Engineering**				
Course Code	AEE015				
Program	B. Tech.				
Semester	VII				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mrs K Harshini, Assistant Professor,EEE				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS006	I	Engineering Physics
B.Tech	AEE006	III	Electro Magnetic Field Theory

II COURSE OVERVIEW:

This course enables Planning, operation and Testing of High voltage Electrical devices. High voltage engineering deals with different mediums of insulation and break down Phenomenon, generation of high DC and AC voltage, measurement Techniques of high AC and DC voltages, testing of insulation under all types of conditions using generated high DC and AC voltages.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
High Voltage Engineering	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
66.7 %	Understand
33.3%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
50%	50%	-

VI COURSE OBJECTIVES:

The students will try to learn:

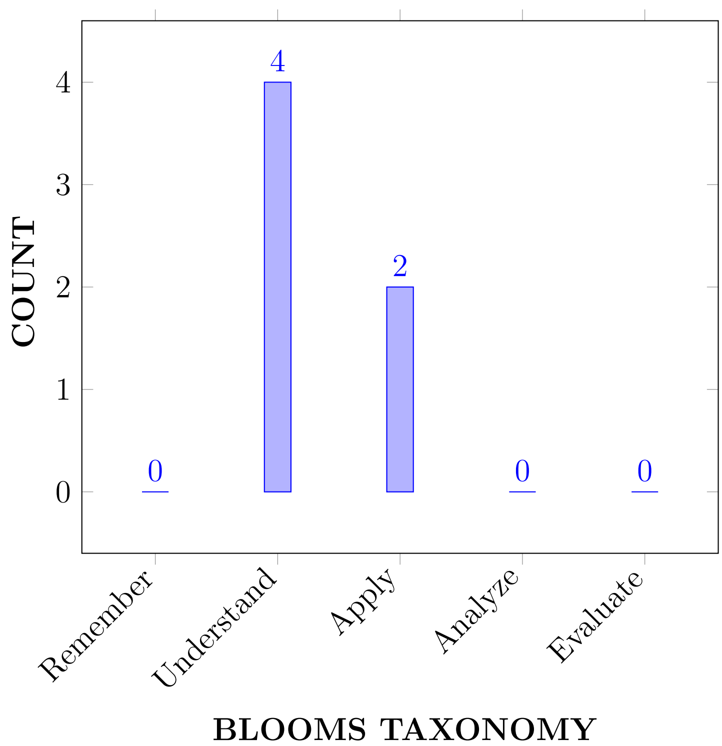
I	The breakdown phenomena in gas, liquid and solid dielectric materials used in the high voltage devices.
II	The circuit design and operation for generation of high DC, AC and impulse voltages.
III	The different methods for measurement and testing of equipments used in the high voltage engineering.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Infer** the protection methods against over voltages and working of lightning arrester for protecting various equipments in power system.	Understand
CO 2	**Illustarte** the breakdown phenomena of various types of dielectric materials to measure their strength in an insulating medium.	Understand
CO 3	**Explain** the methods of generation of impulse voltage and currents for controlling and triggering of impulse generators.	Understand
CO 4	**Apply** analytical and numerical techniques of measuring voltages and currents accurately calculations in high voltage systems.	Apply
CO 5	**Make use of** various nondestructive test techniques used for testing of high voltage electrical apparatus.	Apply
CO 6	**Outline** the principles of insulation co-ordination on high voltage and Extra high voltage power systems for suppressing the over voltages	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/Quiz/AAT
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	CIE/Quiz/AAT
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	2	CIE/Quiz/AAT
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	CIE/Quiz/AAT
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	1	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, develop fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.	1	Research Paper / Quiz / AAT

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Focus on the components of electrical drives with its converter topologies, for energy conversion, management and auditing in specific applications of industry and sustainable rural development.	1	Research Paper / Quiz / AAT

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	✓	-	✓	-	✓	-	✓	✓	✓	-
CO 2	✓	✓	✓	-	-	✓	-	-	-	✓	-	-	-	-	-
CO 3	✓	✓	✓	-	-	✓	-	✓	-	✓	-	-	✓	✓	-
CO 4	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	✓	-
CO 5	✓	✓	✓	-	-	✓	-	✓	-	✓	-	-	✓	✓	-
CO 6	✓	✓	✓	-	-	✓	-	✓	-	-	-	-	✓	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	**PO 1**	Recall about the over voltages in power system for protecting electrical equipment knowledge of mathematics, science and engineering fundamentals.	2
	PO 2	Analyze complex Problems on charge formation techniques using first principles of mathematics, natural sciences, and engineering sciences.	3
	PO 6	Understands the concept of charge formation techniques and over voltages their applications to the contextual knowledge to assess societal engineering practice.	3
	PO 8	Knowledge of over voltages to use their application to professional ethics and responsibilities and norms of the Engineering practice	3
	PO 10	Understands the basics of over voltages of system should be able to communicate effectively on engineering activities	2
	PO 12	Recognize the types of over voltages and charge formation is what we use in daily life through the preparation and ability in personal development.	3
	PSO 1	Design and operate over voltage controlling techniques in electrical systems in order to protect the system.	1
	PSO 2	Understands over voltage and charge formation of a system involving transmission and distribution of Electrical Energy	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	**PO 1**	Provide knowledge about dielectric material characteristics and classify of breakdown strength systems with basic fundamentals of science, and engineering fundamentals.	3
	PO 2	Analyze complex Problems on breakdown strength systems using first principles of mathematics, natural sciences, and engineering sciences.	3
	PO 3	Identify and manage their with stand levels of various dielectric materials that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	6
	PO 6	Understands the concept of classify of breakdown strength systems and dielectric material their applications to the contextual knowledge to assess societal engineering practice.	3
	PO 10	Understands the basics classify of breakdown strength systems should be able to communicate effectively on engineering activities	2
CO 3	**PO 1**	Summarize various techniques used for generating impulse voltages with the knowledge of mathematics, science and engineering fundamentals.	3
	PO 2	Analyse complex Problems on generating impulse voltages using first principles of mathematics, natural sciences, and engineering sciences.	3
	PO 3	Explain the controlling and generation of impulse voltage and current for triggering of impulse generator the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	7
	PO 6	Understands the concept of generating impulse voltages their applications to the contextual knowledge to assess societal engineering practice.	3
	PO 8	Knowledge of generating impulse voltages over voltages to use their application to professional ethics and responsibilities and norms of the Engineering practice	3
	PO 10	Understands the basics of generating impulse voltages should be able to communicate effectively on engineering activities	2
	PSO 1	Design and operate generating impulse voltages in electrical systems in order to protect the system.	1
	PSO 2	Recognize the importance of various generating impulse voltages and currents need of testing various apparatus.	1
CO 4	**PO 1**	Estimate the value of measurement of over voltages for protecting the electrical apparatus using the principles of mathematics and engineering fundamentals.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Analyze complex Problems on breakdown strength systems using first principles of mathematics, natural sciences, and engineering sciences.	3
	PO 3	Design the solution for problems of harmonics and resonance conditions	7
	PO 6	Understands the concept of measurement of impulse voltages their applications to the contextual knowledge to assess societal engineering practice.	3
	PO 8	Knowledge of measurement of impulse voltages over voltages to use their application to professional ethics and responsibilities and norms of the Engineering practice	3
	PO 10	Understands the basics of measurement of impulse voltages should be able to communicate effectively on engineering activities	2
	PSO 1	Design and operate measurement of impulse voltages in electrical systems in order to protect the system.	1
	PSO 2	Summarize and controlling of impulse waves in power system.	1
CO 5	**PO 1**	Summarize power quality issues mitigation techniques use for non disruptive testing's with the help of basic fundamentals of mathematics science and engineering fundamentals.	3
	PO 2	Analyze complex Problems on power quality issues mitigation techniques using first principles of mathematics, natural sciences, and engineering sciences.	3
	PO 3	Utilize various non disruptive test techniques of high voltage that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	6
	PO 6	Understands the concept of disruptive test techniques of high voltage their applications to the contextual knowledge to assess societal engineering practice.	3
	PO 8	Knowledge of disruptive test techniques of high voltage to use their application to professional ethics and responsibilities and norms of the Engineering practice	3
	PO 10	Understands the basics of mdisruptive test techniques of high voltage should be able to communicate effectively on engineering activities	2
	PSO 1	Design and operate transient conditions in electrical systems in order to protect the system.	1
	PSO 2	Summarize the transient conditions with the required electrical power system.	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	**PO 1**	Outline the control and protection and their impact on power systems with the help of basic fundamentals of mathematics science and engineering fundamentals.	3
	PO 2	Analyze complex Problems on insulation of extra high voltage power system using first principles of mathematics, natural sciences, and engineering sciences.	3
	PO 3	Relate the insulation coordination and extra high voltage power system for protecting the system the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	6
	PO 6	Understands the concept of insulation coordination and extra high voltage power system for protecting their applications to the contextual knowledge to assess societal engineering practice.	3
	PO 8	Knowledge of disruptive test techniques of high voltage to use their application to professional ethics and responsibilities and norms of the Engineering practice	3
	PSO 1	Focus on the protection for operation and control of over voltages and extra voltages system.	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	7	-	-	-	3	-	2	-	2	-	2	2	3	-
CO 2	3	3	7	-	-	3	-	-	-	3	-	-	-	-	-
CO 3	3	5	7	-	-	3	-	1	-	2	-	-	3	3	-
CO 4	3	4	7	-	-	3	-	2	-	2	-	-	3	4	-
CO 5	3	5	7	-	-	3	-	2	-	2	-	-	3	4	-
CO 6	3	4	3	-	-	4	-	1	-	-	-	-	2	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	70	-	-	-	60	-	66.7	-	40	-	25	40	9.09	
CO 2	100	30	70	-	-	60	-	100	-	60	-	-	-	-	-
CO 3	100	50	70	-	-	60	-	33.3	-	40	-	-	20	18.2	-
CO 4	100	40	70	-	-	60	-	66.7	-	40	-	-	40	9.09	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 5	100	50	70	-	-	60	-	66.6	-	40	-	-	40	18.2	-
CO 6	100	40	30	-	-	80	-	33.3	-	-	-	-	20	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 - $5 < C \leq 40\%$ – Low/ Slight
2 - $40\% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	2	-	-	-	2	-	1	-	1	-	1	2	1	-
CO 2	2	2	2	-	-	2	-	-	-	1	-	-	-	-	-
CO 3	3	2	2	-	-	2	-	1	-	1	-	-	1	2	-
CO 4	3	3	3	-	-	2	-	1	-	1	-	-	2	1	-
CO 5	3	2	2	-	-	2	-	1	-	1	-	-	2	2	-
CO 6	2	1	1	-	-	3	-	1	-	-	-	-	1	-	-
TOTAL	15	12	10	-	-	13	-	5	-	5	-	1	8	6	-
AVERAGE	2.5	2	1.6	-	-	2.2	-	1	-	1	-	1	1.6	1.5	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	-				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS**
	Origin of over voltages: Causes of over voltages and their effects on power system, lightning, switching surges and temporary over voltages, corona and its effects, reflection and refraction of travelling waves, Protection against over voltages.

MODULE II	**DIELECTRIC BREAKDOWN**
	Breakdown of dielectrics: Gaseous breakdown in uniform and non uniform fields, corona discharges, breakdown of vacuum, conduction and breakdown in pure and commercial liquids, maintenance of oil quality, breakdown mechanisms in solid and composite dielectrics.
MODULE III	**GENERATION OF HIGH VOLTAGES AND HIGH CURRENTS**
	High AC, DC voltages and currents: Generation of high DC, AC and impulse voltages and currents. Triggering: Triggering and control of impulse generators.
MODULE IV	**MEASUREMENT OF HIGH VOLTAGES AND HIGH CURRENTS**
	High voltage and current measurement: High resistance with series ammeter, dividers, resistance, capacitance and mixed dividers, peak voltmeter, generating voltmeters, capacitance voltage Transformers, electrostatic voltmeters, sphere gaps, high current shunts, digital techniques in high voltage measurement.
MODULE V	**HIGH VOLTAGE TESTING AND INSULATION COORDINATION**
	Testing: High voltage testing of electrical power apparatus as per international and Indian standards, power frequency, impulse voltage and dc testing of insulators, circuit breakers, bushings, isolators and transformers, insulation coordination.

TEXTBOOKS

1. 1. S Naidu, V Kamaraju, “High Voltage Engineering”, Tata McGraw-Hill, 5th Edition, 2013.

2. E Kuffel, W S Zaengl, J Kuffel, “High voltage Engineering fundamentals”, Newnes, 2nd Edition Elsevier, New Delhi, 2005.

3. Subir Ray, “An Introduction to High Voltage Engineering”, PHI Learning Private Limited, New Delhi, 2nd Edition, 2013

REFERENCE BOOKS:

1. L L Alston, “High Voltage Technology”, Oxford University Press, 1st Indian Edition, 2011.

2. C L Wadhwa, “High Voltage Engineering”, New Age International Publishers, 3rd Edition, 2010

WEB REFERENCES:

1. https://nptel.ac.in/courses/112105171/1

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	-
CONTENT DELIVERY (THEORY)			
1	Causes of over voltages and their effect	CO 1	T1:1.1
2	Understand switching surges, temporary over voltages.	CO 1	T1:1.1
3	Corona and its effects.	CO 1	T1:1.4-1.6
4	Reflection and refraction of travelling waves	CO 1	T1: 2.4
5	Protection against over voltages	CO 1	T1:2.2
6	Understand Natural causes for over voltages	CO 1	T1:2.2
7	Characteristics of the lightning strokes	CO 1	T1:2.4
8	Switching over voltages	CO 1	T1:2.2
9	Various methods for protection of Transmission lines against Lightning over voltages	CO 1	T1:2.5
10	Surge diverters and Surge modifiers	CO 1	T1:2.5
11	Discuss gases as insulating media, collision process	CO 2	T1: 3.1-3.2
12	Explain Primary ionization process.	CO 2	T1: 1..2
13	Corona discharges, breakdown of vacuum	CO 2	T1 :2.6
14	Breakdown of solid dielectrics	CO 2	T1 :2.6
15	Breakdown in pure and commercial liquids.	CO 2	T1 :5.1-5.2
16	Secondary Ionization process.	CO 2	T1 :5.1-5.2
17	Statement of Townsend's criteria	CO 2	T1: 5.3
18	Circuits for Generation of High Direct Current Voltages.	CO 3	T1: 5.3
19	Discuss Methods to Generation of Impulse Voltages.	CO 3	T1: 5.3
20	Impulse voltages and currents	CO 3	T1: 5.4
21	Full& half Wave rectifier circuit for high DC voltage generation	CO 3	T1: 5.5
22	Cascade transformer to generate high AC voltage	CO 2	T1: 5.5
23	Principle of Hall generator	CO 4	T1:5.8
24	Tripping control of impulse generators.	CO 4	T1: 6.1 -6.2
25	Measurement of high AC Voltages.	CO 4	T1: 6.3 -6.5
26	Measurement of High Direct Current voltages.	CO 4	T1: 7.1 -7.2

27	Measurement of High impulse voltages	CO 4	T1: 7.3
28	Extra High Voltage power systems.	CO 5	T1: 5.6
29	Measurement of D.C Resistivity.	CO 5	T1: 8.1 -8.2
30	Capacitance Voltage Transformers	CO 5	T1: 8.2
31	Electrostatic Voltmeters	CO 5	T1: 8.4
32	Digital Techniques in High Voltage Measurement	CO 5	T1: 8.4
33	Sphere Gaps and High Current Shunts.	CO 4	T1: 9.1-9.4
34	High voltage testing of electrical power apparatus	CO 4	T1: 8.1 -8.2
35	Observe breakdown phenomenon of circuit breakers.	CO 6	T1: 12.1-12.2
36	Power Frequency	CO 6	T1: 12.3-12.4
37	Impulse Voltage and DC Testing Of Insulators	CO 6	T1: 12.4
38	Importance of insulation co-ordination in power system.	CO 6	T1: 12.6
39	Partial discharge test on high voltage cables	CO 6	T1:12.7
40	Transformers insulation coordination.	CO 5	T1:10.3
PROBLEM SOLVING/ CASE STUDIES			
41	Find the voltage rise at the junction due to the surge	CO 1	R1: 2.6
42	Determine the value of the reflected and refracted voltages and current Waves at the junction	CO 1	R1: 2.6
43	Determine the critical descriptive voltage at which corona will occur.	CO 1	R1: 3.2
44	The breakdown strength of air be for small gaps and large gaps	CO 2	R1: 3.2
45	Develop the streamer theory of gas insulation.	CO 2	R1: 4.4 Pg No 195-198
46	Differentiate between short term breakdown and from long term breakdown in composite Di-electric	CO 2	R1: 4.4 Pg No 198-209
47	Calculate ripple percentage, Voltage regulation and optimum number of stages for minimum regulation.	CO 3	R1:5.3 Pg No 285-292
48	Find the wavefront and wave Tail times of the impulse wave produced	CO 3	R1:6.4 Pg No 339-347
49	Calculate the peak current and waveshape of the output current of the generator	CO 3	R1:7.3 Pg No 417-427
50	Determine the value of R and C if the time constant of RC circuit given.	CO 3	R1:7.4 Pg No 452-465

51	Determine the mutual inductance of coil R and C of the integrating circuit.	CO 3	R1:7.3 Pg No 417-427
52	Determine the capacitance of the generating voltmeter	CO 4	R1:10.3 Pg No 594-597
53	Outlinethe relationship betweeni) Disruptive discharge voltage (ii)Creepage distance (iii) Impulse voltage CO 5 (iv)100%flashover voltage.	CO 4	R1: 10.4 Pg No 661-671
54	Draw Chubb-Fortescue Circuit for measurement of peak value of AC voltages	CO 5	R1: 9.2
55	Estimate the values of mutual inductance, resistance, and capacitance to be connected	CO 6	R1: 10.7 Pg No 630-639
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Lighting Strokes, Ferranti Effect, Air Density Factor, Travelling Wave	CO 1	T1: 2.4
57	Thermal breakdown, Electro Chemical Breakdown, electro negative gases, Townsend's second ionization co-efficient	CO 2	T1: 3.1-3.2
58	Voltage Multiplier Circuit, transient voltage, voltage doublers Circuit.	CO 3	T1: 6.3 -6.5
59	Capacitance Voltage Dividers, Current Transformers, potential Dividers.	CO 4	T1: 8.1 -8.2
60	Surge diverter, Partial discharge, Disruptive discharge voltage.	CO 5, CO 6	T1: 12.3-12.4
DISCUSSION OF QUESTION BANK			
61	Various methods to control switching over voltages, lightning arrestor, Corona discharge	CO 1	T1: 2.4
62	Townsend's current growth equation, Streamer theory, breakdown strength of air	CO 2	T1: 3.1-3.2
63	Maximum output voltage of The generator, ripple percentage, Resonant transformer, Voltage regulation, COCK-ROFTWALTON	CO 3	T1: 6.3 -6.5
64	Measurement of high voltages, Capacitance of the generating voltmeter, Generating voltmeter	CO 4	T1: 8.1 -8.2
65	High Voltage Tests, Impulse testing, power frequency tests	CO 5, CO 6	T1: 12.3-12.4

Signature of Course Coordinator **HOD,EEE**

Mrs K Harshini, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF(s)
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences **(Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations **(Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions	**10**

	5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**

PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project.	**12**

	6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	
PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**

PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer. 1. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**POWER PLANT CONTROL AND INSTRUMENTATION**				
Course Code	AEE516				
Program	B.Tech				
Semester	VII				
Course Type	Professional Elective				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. M Laxmidevi Ramanaiah, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE003	III	Power Generation Systems
B.Tech	AEE008	IV	Electrical Measurements and Instrumentation

II COURSE OVERVIEW:

The course focuses on electric power generation concepts. In addition to the power generation technologies adopted to generate electric power, power plant instrumentation is also included. The various control techniques adopted in power plants are discussed. The course would provide an insight to the students who want to pursue research in power plant engineering.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Power Plant Control and Instrumentation	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
30%	Understand
20%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz/ Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

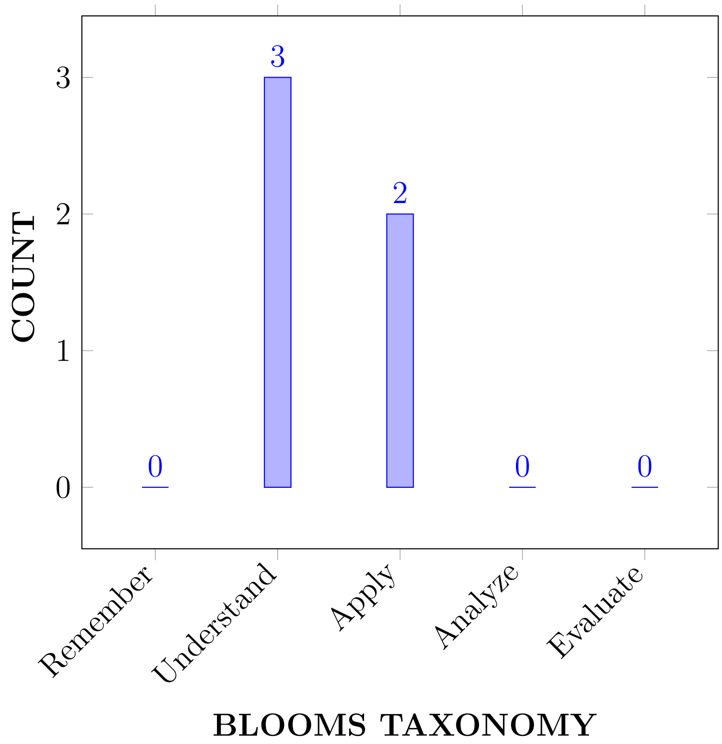
I	The operation of different types of power plants.
II	The basic working principle of instruments for measurement of electrical and non-electrical quantities like Temperature Pressureflow level measurements.
III	The instrumentation and protection systems applied in thermal power plant.
IV	The control techniques employed for the operation of modern power generation plant

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the different methods of power generation . along with Piping and Instrumentation diagram of boiler.	Understand
CO 2	**Select** various measurements involved in power generation for measuring electrical and non-electrical parameters .	Understand
CO 3	**Identify** the different types of analyzers used for scrutinizing boiler steam and water.	Understand
CO 4	**Model** different types of controls and control loops in boilers.	Apply
CO 5	**Illustrate** the methods of monitoring and control of different parameters like speed, vibration of turbines.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations

Program Outcomes	
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/CIA
PO 2	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	SEE/CIA
PO 3	Design/Development of Solutions: Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	SEE/CIA

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	SEE/CIA
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	SEE/CIA
PO 10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	SEE/CIA
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	SEE/CIA

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	1	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	✓	-	-	✓	-	-	-	✓	-	✓	✓	-	-
CO 2	✓	-	✓	✓	-	✓	-	-	-	-	-	✓	-	-	-
CO 3	✓	-	-	-	-	✓	-	-	-	-	-	✓	-	-	-
CO 4	✓	-	✓	-	✓	✓	-	-	-	-	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 5	✓	-	✓	-	-	✓	-	-	-	-	-	-	-	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall the electricity generating methods using the using the principles of mathematics, science and engineering fundamentals.	3
	PO 2	Interpret the piping and instrumentation diagrams of boiler **to solve complex engineering problems using principles ofmathematics and engineering sciences.**	3
	PO 3	**Design the solution for problems** to minimize losses in power generation.	5
	PO 6	Determine the adverse effects of traditional power generation methods related to health issues and suggest methods to promote sustainable development.	2
	PO 10	Demonstrate the ability **to communicate effectively** the problems in thermal power plants.	2
	PO 12	Recognize the need for **advanced engineering concepts** and learn new significant skills.	2
	PSO 1	Develop efficient operation of thermal power plants and **familiarize with the safety and health norms.**	2
CO 2	PO 1	Recall the concepts of power generation **using the principles of mathematics,science and engineering fundamentals.**	3
	PO 3	**Design the solution** for accurate measurement of different quantities.	3
	PO 4	Make use of the knowledge of characteristics of measuring instruments **to assess quality issues**.	3
	PO 6	Illustrate the operation of various intruments **for safety issues in professional engineering practice**	2
	PO 12	Recognize the need for advanced engineering concepts in power generation.	1
CO 3	PO 1	Recall the types of impurities in power plants using the principles of mathematics,science and engineering fundamentals.	3
	PO 6	Make use of contextual knowledge to assess health, safety and legal issues involved in generating electricity by various sources.	2
	PO 12	Make use of the knowledge of characteristics of measuring instruments to assess quality issues.	1
CO 4	PO 1	Recall the types of boiler **using the principles of mathematics,science and engineering fundamentals.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 3	Ensure efficient operation of boiler **considering commercial and economic context of engineering processes.**	3
	PO 5	Understand the different types of controls and control loops **modelling using IT tools**	1
CO 5	PO 6	Make use of the knowledge of characteristics of measuring instruments **to assess quality issues.**	2
	PO 1	Recall the types of turbines **using the principles of mathematics,science and engineering fundamentals.**	3
	PO 3	Ensure efficient operation of turbine and cooling systems **considering commercial and economic context of engineering processes**	3
	PO 4	Understand the methods of speed control **with analysis and interpretation of data**.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	5	-	-	2	-	-	-	2	-	2	2	-	-
CO 2	3	-	3	3	-	2	-	-	-	-	-	1	-	-	-
CO 3	3	-	-	-	-	2	-	-	-	-	-	-	-	-	-
CO 4	3	-	3	-	1	2	-	-	-	-	-	-	-	-	-
CO 5	3	-	3	-	-	2	-	-	-	-	-	-	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	30	40	-	-	40	-	-	-	30	-	25	40	-	-
CO 2	100	-	30	30	-	40	-	-	-	-	-	12.5	-	-	-
CO 3	100	-	-	-	-	40	-	-	-	-	-	12.5	-	-	-
CO 4	100	-	30	-	-	40	-	-	-	-	-	-	-	-	-
CO 5	100	-	30	-	-	40	-	-	-	40	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 - $5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	1	-	-	2	-	-	-	1	-	1	1	-	-
CO 2	3	-	1	1	-	2	-	-	-	-	-	1	-	-	-
CO 3	3	-	-	-	-	2	-	-	-	-	-	1	-	-	-
CO 4	3	-	1	-	1	2	-	-	-	-	-	-	-	-	-
CO 5	3	-	1	-	-	2	-	-	-	-	-	-	-	-	-
TOTAL	15	1	4	1	1	10	-	-	-	1	-	3	1	-	-
AVERAGE	3	1	1	1	1	2	-	-	-	1	-	1	1	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	-	-	-	-	

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

UNIT I	**OVERVIEW OF POWER GENERATION**
	IBrief survey of methods of power generation, hydro, thermal, nuclear, solar and wind power, importance of instrumentation in power generation, thermal power plants, block diagram, details of boiler processes, Piping and Instrumentation diagram of boiler, cogeneration
UNIT II	**MEASUREMENTS IN POWER PLANTS**
	Electrical measurements, current, voltage, power, frequency, power factor,etc, non-electrical parameters, flow of feed water, fuel, air and steam with correction factor for temperature, steam pressure and steam temperature, drum level measurement, radiation detector, smoke density measurement, dust monitor
UNIT III	**ANALYSERS IN POWER PLANTS**
	Flue gas oxygen analyzer: Analysis of impurities in feed water and steam, dissolved oxygen analyzer, Chromatography, pH meter, fuel analyzer, pollution monitoring instruments.
UNIT IV	**CONTROL LOOPS IN BOILER**
	Combustion control, air / fuel ratio control, furnace draft control, drum level control, main steam and reheat steam temperature control, super heater control, air temperature, distributed control system in power plants, interlocks in boiler operation.

UNIT V	**TURBINE MONITORING AND CONTROLS**
	Speed, vibration, shell temperature monitoring and control, steam pressure control, lubricant oil temperature control, cooling system.

TEXTBOOKS

1. Sam G. Dukelow, 'The Control of Boilers', Instrument Society of America, 2nd Edition,2010

2. 2. P.K. Nag, 'Power Plant Engineering', Tata McGraw-Hill, 1st Edition,2001

REFERENCE BOOKS:

1. S.M. Elonka and A.L. Kohal, "Standard Boiler Operations", Tata McGraw-Hill, 1st Edition,1994.

2. R K Jain, "Mechanical and Industrial Measurements", Khanna Publishers, 1st Edition,1995.

3. 3. E Al Wakil, "Power Plant Engineering", Tata McGraw-Hill, 1st Edition,1984.

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Presentation on Outcome based education		
CONTENT DELIVERY (THEORY)			
2	Different methods of power generation	CO 1	T2: 1.1
3 -4	Hydro, thermal, nuclear, solar and wind power	CO 1	T2: 1.4
5	importance of instrumentation in power generation	CO 1	T2: 8.1
6-7	details of boiler processes	CO 1	T2: 8.8
8	Piping and Instrumentation diagram of boiler	CO 1	T1: 8.6
9-10	cogeneration.r	CO 2	R1: 14.1
11-12	Measurement of electrical quantities like voltage, current, power, frequency and power factors	CO 2	T1: 12.12
13-14	Measurement of non-electrical quantities like flow of feed water, fuel and air.	CO 2	T1: 12.21
15-16	Measurement of non-electrical quantities like steam, temperature, pressure, radiation, smoke and dust	CO 2	T1: 9.5
17	Measurement of non-electrical quantities like radiation, smoke and dust.	CO 2	T1: 9.1
18	flue gas oxygen analyzer	CO 3	R2:9.7
18	method of chromatography.	CO 3	R1: 10.3
19-20	concept of fuel analyzer and pH meter..	CO 3	R: 10.19
21	Pollution monitoring instruments.	C0 3	T1: 10.21
22-23	combustion control, air/fuel control, furnace draft control.	CO 4	T1: 11.6
24-25	control of drum level, main steam and reheat steam temperature.	CO 4	T1: 10.5

26-27	super heater control, air temperature control	CO 4	T1: 10.2
28	distributed control system in power plants	CO 4	T1: 10,2
29-30	interlocks in boiler operation	CO 4	T1: 11.1
31-32	turbine operation to control the speed, vibration and shell temperature	CO 5	T1: T2:7
33	different cooling systems available	CO 5	T2:8.6
DISCUSSION OF DEFINITION AND TERMINOLOGY			
34	Piping and instrumentation diagrams	CO 1	T2:1.1
35	Electrical and non-electrical parameters	CO 2	T2:14.1
36	Analyzers	CO 3	T2:10.1
37	Boiler controls	CO 4	T1:13.1
38	Turbine controls	CO 5	T1:21.1
DISCUSSION OF QUESTION BANK			
61	UNIT I : Hydel,Thermal, Solar, Wind power plants	CO 1	T2:1.1
62	UNIT II : Current, Voltage, Power, Frequency, Power factor, Temperature, Steam pressure, drum level measurement	CO 2	T2:14.1
63	UNIT III : Power plany analysers	CO 3	T2:10.1
64	UNIT IV:Combustion control, furnace draft control, drum level control, temperature control	CO 4	T1:13.1
65	UNIT V: Turbine speed, shell temperature and steam pressure control, cooling system	CO 5	T1:21.1

Signature of Course Coordinator **HOD,EEE**
Dr M Laxmidevi Ramanaiah

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences **(Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations **(Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**

PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**

PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**

PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**
PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**
PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer. 1. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRON ICS ENGINEERING

COURSE DESCRIPTION

Course Title	**High Voltage Engineering and Solar Laboratory**				
Course Code	AEE111				
Program	B.Tech				
Semester	VII	EEE			
Course Type	Core				
Regulation	R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Mr. A Sathish kumar, Assistant Professor				

I COURSE OVERVIEW:

TThe objective of this course is to conduct experiments with different breakdown medium of insulation, measurement of high AC and DC voltages, testing of insulation under all types of conditions using generated high DC and AC voltages and this course includes experiments deal with solar power measurement technology.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE006	III	Electro Magnetic Field Theory

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
High Voltage Engineering and Solar Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	-
20 %	Analysis	-
20 %	Design	-
20 %	Conclusion	-
20 %	Viva	-

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

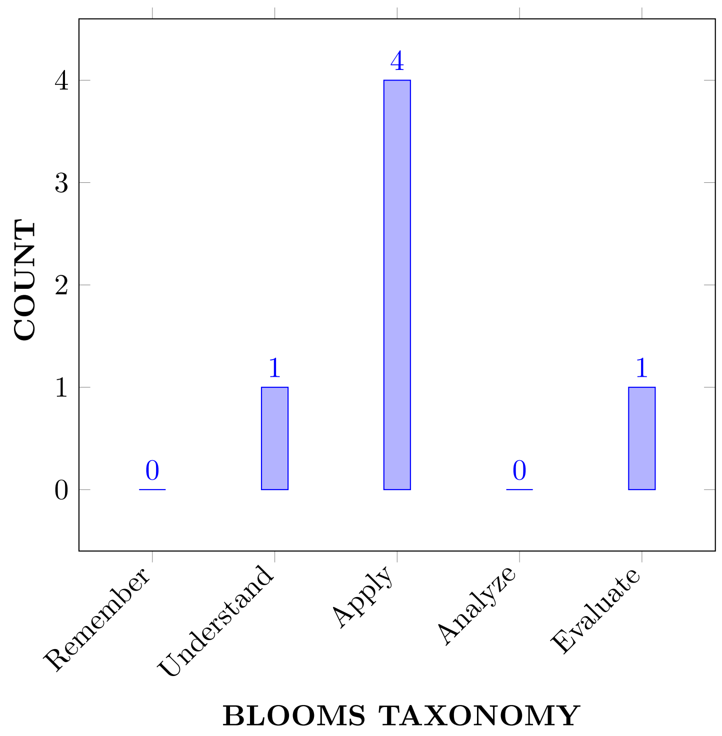
I	The breakdown phenomenon of air using various electrode geometrics.
II	The functionalities of automatic insulting oil testing machine..
III	The polarity of I-V Characteristic in a fixed and solar tracking photovoltaic systems illuminated by an incandescent lamp, at different frequencies.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Make use of** the cascaded transformers for the generation of AC high voltages.. .	Apply
CO 2	**Determine** the breakdown voltage of atmospheric air and solid insulators using rod and sphere gap apparatus.	Evaluate
CO 3	**Examine** the breakdown phenomena in liquid insulator using oil insulation tester.	Apply
CO 4	**Calculate** the equivalent circuit parameters of a PV array for drawing the I - V characteristics.	Understand
CO 5	**Analyze** the performance of the solar panel under various temperatures, tilt angles and shading effects.	Apply
CO 6	**Develop** the mathematical model of PV cell, ensure MPPT algorithm using simulation tools..	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Program Outcomes	
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	Lab Exercises

PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3	Lab Exercises
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	Lab Exercises
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	Lab Exercises
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Lab Exercises
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	**Justification for mapping (Students will be able to)**	No. of Key Competencies
CO 1	PO 1	Observe the working of cascaded transformers using varius electrode geometric for the generation of AC high Voltages using **principles of mathematics and engineering science**	2
	PO 2	Understand the working of cascaded transformers using mathematical model **with problem statement by analyzing complex engineering problems.** for generation of AC high voltages	6
	PO 3	Demonstrate the cascaded transformers for the generation of AC high voltages **to design solutions of complex engineering problems**	6
	PO 4	Understand the working of cascaded transformer using mathematical model **with analysis and interpretation of data** for generation of AC high voltages	6
	PO 6	Illustrate the working of cascaded transformers using mathematical model for generation of AC high voltages and **for safety issues in professional engineering practice**	4
	PSO 1	Demonstrate the working of cascaded transformer using mathematical model for the generation of AC high voltages **to use in the electrical systems involved in power genration, transmikssion and distribution**	3
CO 2	PO 1	determine the breakdown voltages of atmospheric air and solid insulators using rod and sphhere gap apparatus by **principles of mathematics and engineering sciences**	2
	PO 2	Understand the breakdown voltages of atmospheric air and solid insulators using rod and sphhere gap apparatus with**problem statement by analyzing complex engineering problems.**	6
	PO 3	Determine he breakdown voltages of atmospheric air and solid insulators using rod and sphhere gap apparatus **for design solutions of complex engineering problems**	6
	PO 4	Understand thehe breakdown voltages of atmospheric air and solid insulators using rod and sphhere gap apparatus **with analysis and interpretation of data**	6
	PO 6	Illustrate the breakdown voltages of atmospheric air and solid insulators using rod and sphhere gap apparatus **for safety issues in professional engineering practice**	4
	PO 12	Understand the breakdown voltages of atmospheric air and solid insulators using rod and sphhere gap apparatus **in life long learning in technological change**	6

	PSO 1	Demonstrate the he breakdown voltages of atmospheric air and solid insulators using rod and sphhere gap apparatus **in the electrical systems involved in power genration, transmikssion and distribution**	3
CO 3	PO 1	determine the breakdown voltages in liquid insulators using oil insulator tester by **principles of mathematics and engineering sciences**	2
	PO 2	Understand the breakdown voltages in liquid insulators using oil insulator tester with**problem statement by analyzing complex engineering problems.**	6
	PO 3	Determine the breakdown voltages in liquid insulators using oil insulator tester **for design solutions of complex engineering problems**	6
	PO 4	Understand the breakdown voltages in liquid insulators using oil insulator tester **with analysis and interpretation of data**	6
	PO 6	Illustrate the breakdown voltages in liquid insulators using oil insulator tester **for safety issues in professional engineering practice**	4
	PO 12	Understand the breakdown voltages in liquid insulators using oil insulator tester **in life long learning in technological change**	6
	PSO 1	Demonstrate the breakdown voltages in liquid insulators using oil insulator tester **in the electrical systems involved in power genration, transmikssion and distribution**	3
CO 4	PO 1	Observe the I- V characteristics using PV array to calculate equivallent circuit parameters by using **principles of mathematics and engineering science**	2
	PO 2	Understand the I- V characteristics using PV array to calculate equivallent circuit parameters **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the I- V characteristics using PV array to calculate equivallent circuit parameters **for design solutions of complex engineering problems**	6
	PO 4	Understand the I- V characteristics using PV array to calculate equivallent circuit parameters **with analysis and interpretation of data**	6
	PO 5	Understand the I- V characteristics using PV array to calculate equivallent circuit parameters and **modelling using IT tools such as MATLAB**	6
	PO 6	Illustrate the I- V characteristics using PV array to calculate equivallent circuit parameters **for safety issues in professional engineering practice**	4
	PO 10	Interpret the I- V characteristics using PV array to calculate equivallent circuit parameters **with communication of complex engineering practices**	3

	PO 12	Understand the I- V characteristics using PV array to calculate equivallent circuit parameters **in life long learning in technological change**	6
	PSO 1	Demonstrate the I- V characteristics using PV array to calculate equivallent circuit parameters **in the electrical systems involved in power genration, transmikssion and distribution**	3
CO 5	PO 1	understand the performance of solar panel under various temperatures, tilt angles and shading effects using **principles of mathematics and engineering science**	2
	PO 2	Understand he performance of solar panel under various temperatures, tilt angles and shading effects **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate he performance of solar panel under various temperatures, tilt angles and shading effects **for design solutions of complex engineering problems**	6
	PO 4	Understand he performance of solar panel under various temperatures, tilt angles and shading effects **with analysis and interpretation of data**	6
	PO 6	Illustrate he performance of solar panel under various temperatures, tilt angles and shading effects**for safety issues in professional engineering practice**	4
	PO 12	Understand he performance of solar panel under various temperatures, tilt angles and shading effects **in life long learning in technological change**	6
	PSO 1	Demonstrate he performance of solar panel under various temperatures, tilt angles and shading effects **in the electrical systems involved in power genration, transmikssion and distribution**	3
CO 6	PO 1	develop the mathematical model of PV cell, ensure MPPT algorithm using **principles of mathematics and engineering science**	2
	PO 2	Understand the mathematical model of PV cell, ensure MPPT algorithm using simulation tools **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the mathematical model of PV cell, ensure MPPT algorithm using simulation tools **for design solutions of complex engineering problems**	6
	PO 4	Understand the mathematical model of PV cell, ensure MPPT algorithm using simulation tools **with analysis and interpretation of data**	6
	PO 5	Understand the mathematical model of PV cell, ensure MPPT algorithm **modelling using IT tools such as MATLAB**	6
	PO 12	Understand the mathematical model of PV cell, ensure MPPT algorithm using simulation tools **in life long learning in technological change**	6

	PSO 1	Demonstrate the mathematical model of PV cell, ensure MPPT algorithm using simulation tools **in the electrical systems involved in power genration, transmikssion and distribution**	3

XII MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	6	6	6	-	4	-	-	-	-	-	-	3	-	-
CO 2	2	6	6	6	-	4	-	-	-	-	-	6	3	-	-
CO 3	2	6	6	6	-	4	-	-	-	-	-	6	3	-	-
CO 4	2	6	6	6	6	4	-	-	-	3	-	6	3	-	-
CO 5	2	6	6	6	-	4	-	-	-	-	-	6	3	-	-
CO 6	2	6	6	6	6	4	-	-	-	-	-	6	3	-	-

XIII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIV ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XV SYLLABUS:

WEEK I	**GENERATION OF AC HIGH VOLTAGES**
	Study of generation of AC high voltages using cascaded transformers.
WEEK II	**VERIFICATION OF BREAKDOWN POTENTIAL OF AIR AT SPECIFIED GAP**
	Verification of breakdown potential with reference to empirical formula.
WEEK III	**DETERMINE THE BREAKDOWN VOLTAGE OF AIR BY ROD GAP APPARATUS**
	Determination of breakdown voltage of atmospheric air using rod gap apparatus..
WEEK IV	**DETERMINE BREAKDOWN VOLTAGE OF AIR USING SPHERE GAP APPARATUS**
	Determination of breakdown voltage of atmospheric air using sphere gap apparatus.

WEEK V	**DETERMINATION OF BREAKDOWN VOLTAGE OF SOLID INSULATOR**
	Determination of breakdown of solid insulators such as paper, thermocol and glass..
WEEK VI	**DETERMINATION OF BREAKDOWN VOLTAGE OF LIQUID INSULATOR**
	Determination of breakdown of liquid insulator using oil insulation tester..
WEEK VII	**CHARACTERSTICS OF SOLAR PANEL**
	Determination of I-V characteristics of solar panel and calculation of equivalent circuit parameters of a PV array..
WEEK VIII	**SOLAR INVERTER**
	Study the off-grid solar inverter with battery charging controller.
WEEK IX	**EFFECT OF SHADING ON SOLAR PANNEL PERFORMANCE**
	Study a. Series parallel connections of solar panels and effect of shading. b. Improvement in power efficiency of photovoltaic array under shading conditions using bypass diode with PSCAD.
WEEK X	**EFFECT OF TEMPERATURE AND TILT ANGLE ON SOLAR PANNEL**
	Study the effect of surrounding temperature and tilt angle on the performance solar PV panel.
WEEK XI	**DESIGN OF SOLAR PANEL**
	Study the solar panel manufacturing using solar cells by interconnecting them to get desired voltage and power rating.
WEEK XII	**DATA ACQUISITION USING DIGITAL SIMULATION**
	Data acquisition using temperature, voltage and irradiation with sensors of solar panel using digital simulation.
WEEK XIII	**MAXIMUM POWER POINT TRACKER USING DIGITAL SIMULATION / PSCAD**
	a. Implementation of maximum power point tracker using Perturb and Observe algorithm using digital simulation. b. Determine the mathematical model of PV cell, ensure MPPT algorithm using PSCAD.
WEEK XIV	**DETERMINATION OF PARAMETERS OF SOLAR CELL USING DIGITAL SIMULATION**
	Study the characteristics and determination of parameters of solar cell using digital simulation.

TEXTBOOKS

1. S Naidu, V Kamaraju, "High Voltage Engineering", Tata McGraw-Hill, 5th Edition, 2013

2. E Kuffel, W S Zaengl, J Kuffel, "High voltage Engineering fundamentals", Newnes, 2nd Edition Elsevier, New Delhi, 2005

REFERENCE BOOKS:

1. . L L Alston, "High Voltage Technology", Oxford University Press, 1st Indian Edition, 2011

2. 2.C L Wadhwa, "High Voltage Engineering", New Age International Publishers, 3rd Edition, 2010.

XVI COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Study of generation of AC high voltages using cascaded transformers..	CO 1	R1: 1.2
2	Verification of breakdown potential with reference to empirical formula..	CO 2	R2: 3.5
3	Determination of breakdown voltage of atmospheric air using rod gap apparatus.	CO 2	R1: 3.4
4	DDetermination of breakdown voltage of atmospheric air using sphere gap apparatus.	CO 2	R1: 2.2
5	Determination of breakdown of solid insulators such as paper, thermocol and glass.	CO 2	R1: 2.4
6	Determination of breakdown of liquid insulator using oil insulation tester..	CO 3	R3: 4.5
7	Determination of I-V characteristics of solar panel and calculation of equivalent circuit parameters of a PV array..	CO 4	R3: 4.6
8	Study the off-grid solar inverter with battery charging controller.	CO 4	R2: 5.1
9	Study a. Series parallel connections of solar panels and effect of shading. b. Improvement in power efficiency of photovoltaic array under shading conditions using bypass diode with PSCAD..	CO 5	R2: 5.2
10	Study the effect of surrounding temperature and tilt angle on the performance solar PV panel.	CO 5	R1: 7.1
11	Study the solar panel manufacturing using solar cells by interconnecting them to get desired voltage and power rating.	CO 6	R1:7.2
12	Data acquisition using temperature, voltage and irradiation with sensors of solar panel using digital simulation.	CO 6	R1:7.3
13	a. Implementation of maximum power point tracker using Perturb and Observe algorithm using digital simulation. b. Determine the mathematical model of PV cell, ensure MPPT algorithm using PSCAD.	CO 6	R2: 7.1
14	Study the characteristics and determination of parameters of solar cell using digital simulation.n.	CO 6	R3: 8.1

XVII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Twin vortex formation:** Determination of IV characteristics of solar panel and calculation of equivalent circuit parameters of a PV array in PSCAD
2	**Open channel:** Data acquisition using temperature, voltage and irradiation with sensors of solar panel using digital simulation .

Signature of Course Coordinator **HOD,EEE**
Mr.A Sathish Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRONICS ENGINEERING
COURSE DESCRIPTION

<table>
<tr><td>Course Title</td><td colspan="5">POWER SYSTEM PROTECTION LABORATORY</td></tr>
<tr><td>Course Code</td><td colspan="5">AEE112</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td>VII</td><td colspan="4">EEE</td></tr>
<tr><td>Course Type</td><td>Core</td><td colspan="4"></td></tr>
<tr><td>Regulation</td><td>IARE - R16</td><td colspan="4"></td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>3</td><td>1.5</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Mr. T Mahesh, Assistant Professor</td></tr>
</table>

I COURSE OVERVIEW:

Power system protection laboratory is to provide an overview of the principles of protection devices such as miniature circuit breaker, High rupturing fuse and relays. This course focuses on the functioning of protective circuits under fault conditions of transmission lines, feeders and analyze theirperformance. This course also includesprotection of system components from overloads, the probability of fires and other catastrophic system failures can be minimized.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE007	IV	AC machines

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Electrical Power Systems Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner,

both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

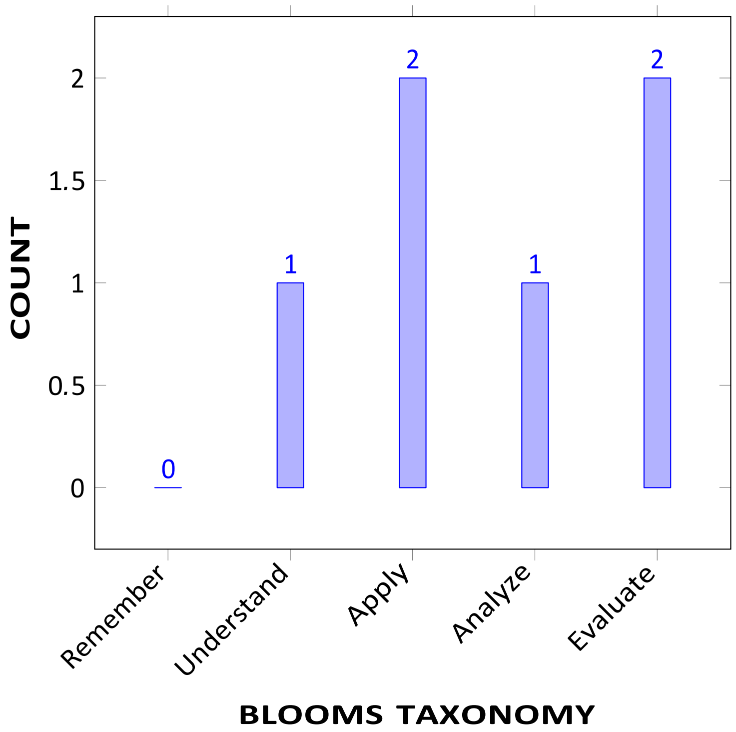
I	The importance of protection in electrical power system and working of fundamental protective devices.
II	The transmission line parameters, surge impedance loading, efficiency, voltage regulation, observe and minimize the Ferranti effect which occurs in voltage of a transmission lines operating conditions.
III	The various distance schemes in over current protection of feeders under three-phase faults.
IV	The necessity of finding sequence components of alternators by using direct and indirect methods.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Examine** the functioning of miniature circuit breaker (MCB) and fuse to plot time-current characteristics.	Analyze
CO 2	**Compute** generalized circuit parameters and surge impedance loading in terms of input and output parameters to analyse performance of a transmission line.	Evaluate
CO 3	**Identify** suitable compensation technique to stabilize and mitigateFerranti effect in atransmission line.	Apply
CO 4	**Understand** the concept of voltage improvement by reactive power control using tap changing transformer.	Understand
CO 5	**Describe** the performance of a transmission line by calculating its efficiency and regulation.	Evaluate
CO 6	**Describe** the working of impedance relay, overcurrent relay during normal and abnormal fault conditions for protection of transmission line.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program	Strength	Proficiency Assessed by

PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Experi-ments/CIE / SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Day -to- Day evaluation sheets
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3	CIA
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.s	2	Lab Experiments / CIE / SEE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	2	Lab Exper-iments / CIE / SEE

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Observe the functionality (knowledge) of protective devices for voltage current characteristics using **principles of mathematics and engineering science**	2
	PO 2	Understand the given power protective device application **problem statement by analyzing complex engineering problems**	4
	PO 3	Identify the transmission line parameters and its the importance of for analyzing electrical networks using **environment, safety and risk**	2
CO 2	PO 1	Evaluate the transmission line parameters and its the importance of for analyzing electrical networks using **principles of Mathematics, Science and Engineering**	2

	PO 4	Understand the (given **problem statement**) effects of viscosity, and capillary rise for the bodies immersed in fluids. (from the provided **information**) in solving analysis problems.	3
CO 3	PO 1	Understand (**knowledge**) the need of Shunt compensation circuits using textbfprinciples of Mathematics, Science and Engineering	3
	PO 4	Recognizethe Ferranti effect by observing sending end and receiving end voltages and understand the corresponding context of the **e**ngineering knowledge, technical uncertainty**of the transmission line.**	3
	PSO 1	Compute the **limits on type of transmission and contributed to the power system protection**	2
CO 4	PO 1	Understand necessity of voltage profile improvement of transmission line **using the knowledge of mathematics and engineering fundamentals.**	2
	PO 2	Demonstrate the operation tap changing transformer in voltage profile improvement using by **analyzing complex engineering problems**	4
	PO 4	Formulate and Evaluate the inverter circuits with **Converter Topologies for Energy Conversion**	2
CO 5	PO 1	Calculate efficiency and voltage regulation of single phase transmission line by **analyzing complex engineering problems**	4
	PSO 1	Compute the **limits on type of transmission and contributed to the power system protection**	2
CO 6	PO 1	Apply (knowledge) the relay characteristics for the operation of relays by using the principles by **Mathematics and Engineering fundamentals.**	2
	PO 2	Understand the applications of relays in the protection by electrical system by **analyzing complex engineering problems**	4
	PO 4	Understand the applications of relays in the protection by electrical system by **analyzing complex engineering problems.**	2

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES			PSO'S
	PO 1	PO 3	PO 4	PSO 3
CO 1	2	3		3
CO 2	2		2	3
CO 3	2	3		3
CO 4	2		2	3
CO 5	2	3	2	3

CO 6	2	3		

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1, PO 2, PO 3, PO 4, PSO 1	SEE Exams	PO 1,PO 2, PO 3, PO4 PSO 1	Seminars	-
Laboratory Practices	PO 1,PO 2, PO 3, PSO 1	Student Viva	PO 1, PO 2	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

√	Early Semester Feedback	√	End Semester OBE Feedback
✗	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**CHARACTERISTICS OF AN MCB**
	Plotting the Characteristics of Miniature Circuit Breaker (MCB).
WEEK II	**CHARACTERISTICS OF FUSE AND THERMAL OVERLOAD PROTECTION**
	Study of characteristics of High Rupturing Capacity (HRC) fuse and tripping of bimetallic thermal overload protection and its characteristics.
WEEK III	**ABCD PARAMETERS OF TRANSMISSION LINE**
	Measurement of ABCD parameters of a transmission line
WEEK IV	**FERRANTI EFFECT IN A TRANSMISSION LINE**
	Study of Ferranti effect in a the transmission line
WEEK V	**SURGE IMPEDANCE LOADING**
	Study of Surge Impedance Loading (SIL) of a transmission line.
WEEK VI	**EFFECT OF SHUNT COMPENSATION**
	Determine shunt compensation to counteract the voltage rise on no load and zero regulation at different loads in a transmission line.
WEEK VII	**VOLTAGE PROFILE IMPROVEMENT USING TAP CHANGING TRANSFORMER**
	Study of voltage improvement by reactive power control using tap changing transformer.
WEEK VIII	**EFFICIENCY AND REGULATION OF A TRANSMISSION LINE**

	Determine the performance of a transmission line by calculating its efficiency and regulation..
WEEK IX	**PERFORMANCE OF IMPEDANCE RELAY**
	Study the working principle of impedance relay and its effect during faults in a transmissionline.
WEEK X	**PERFORMANCE OF OVER CURRENT RELAY**
	Study the working principle of over current relay and its effect during faults in a transmission line.
WEEK XI	**EARTH FAULT PROTECTION**
	Study of earth fault detection methods and various earth fault protection schemes.
WEEK XII	**FEEDER PROTECTION**
	Study the various protection schemes in radial feeder under various fault conditions.
WEEK XIII	**MEASURMENT OF SEQUENCE IMPEDANCES OF SYNCHRONOUS MACHINE**
	Measurement of positive, negative and zero sequence impedances of synchronous machine by using direct method and fault analysis method.
WEEK XIV	**STRING EFFICIENCY OF INSULATORS**
	Determination of string efficiency in a string of insulators.

TEXTBOOKS

1. Sunil S Rao, “Switchgear and Protection”, Khanna Publishers, 1st Edition, 2013.
2. Badari Ram, D N Viswakarma, “Power System Protection and Switchgear”, TMH Publications, 1 st Edition, 2001.
3. B L Soni, Gupta, Bhatnagar, Chakrabarthy, “Power System Engineering”, Dhanpat Rai Co, 3 rd Edition, 2007.
4. T S Madhava Rao, “Power system protection: static relays”, McGraw-Hill Companies, 2 nd Edition, 1989.

REFERENCE BOOKS:

1. Paithankar, S R Bhide, “Fundamentals of Power System Protection”, PHI, 1st Edition, 2003.
2. C LWadhwa, “Electrical Power Systems”, New Age international (P) Limited, 6th Edition, 2010.
3. VK Mehta, ”Principles of power systems”, S Chand Publications, 4th Edition, 2009.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO’s	Reference
1	Characteristics of Miniature Circuit Breaker.	CO 1	R1: 1.2
2	Study of characteristics of High Rupturing Capacity (HRC) fuse and tripping of bimetallic thermal overload protection and its characteristics.	CO 1	T1: 3.11

3	ABCD parameters of transmission line.	CO 2	T1: 4.8
4	Ferranti effect of a transmission line.	CO 2	T1: 4.8
5	Surge Impedance Loading (SIL) of transmission line.	CO 2	T1: 5.5
6	Determine shunt compensation to counteract the voltage rise on no load and zero regulation at different loads in a transmission line	CO 3	TR3: 5.5
7	Study of voltage improvement by reactive power control using tap changing transformer.	CO 4	T3: 8.3
8	Determine the performance of a transmission line by calculating its efficiency and regulation.	CO 5	R2: 8.3
9	Study the working principle of impedance relay and its effect during faults in a transmission line.	CO 6	T1: 9.2
10	Understand the working principle of over current relay and its effect during faults in a transmission line.	CO 6	T1: 10.2
11	Study of earth fault detection methods and various earth fault protection schemes.	CO 5	T1:10.7
12	Understand the various protection schemes in radial feeder under various fault conditions.	CO 5	T1:10.6
13	Measurement of positive, negative and zero sequence impedances of synchronous machine by using direct method and fault analysis method.	CO 6	T1:10.7
14	Determination of string efficiency in a string of insulators.	CO 6	T1:10.8

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**System Parameter Calculation:** Design of three phase transmission line using distributed resistance, inductance and capacitance.
2	**Fault Compensation:** Determine generalized circuit parameters, observe Ferranti effect, effect of surge impedance loading on a transmission line.
3	**Balanced Three-Phase System** Measurement of sequence impedances of synchronous machine by using simulation software.
4	**Renewable Energy System:** Design of renewable based grid connected power systems using simulation software.
5	**Transmission Line:** Design and develop 400kv, 300kmlong transmission line using simulation tools

Signature of Course Coordinator **HOD,EEE**
Mr. T Mahesh, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTION

Course Title	**Power System Computer Aided Design Laboratory**				
Course Code	AEE113				
Program	B.Tech				
Semester	VII	EEE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Mr. A Naresh Kumar, Assistant Professor				

I COURSE OVERVIEW:

The power system simulation laboratory introduces the program skills using PSCAD and MATLAB through experiments. This laboratory gives emphasis on single line diagram, load flow anlayis, different power protection schemes, fault analysis and various power quality issues using simulation. PSCAD provides key building custom models in any electrical engineering related applications.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB22	VI	Power System Analysis

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Power System Simulation Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

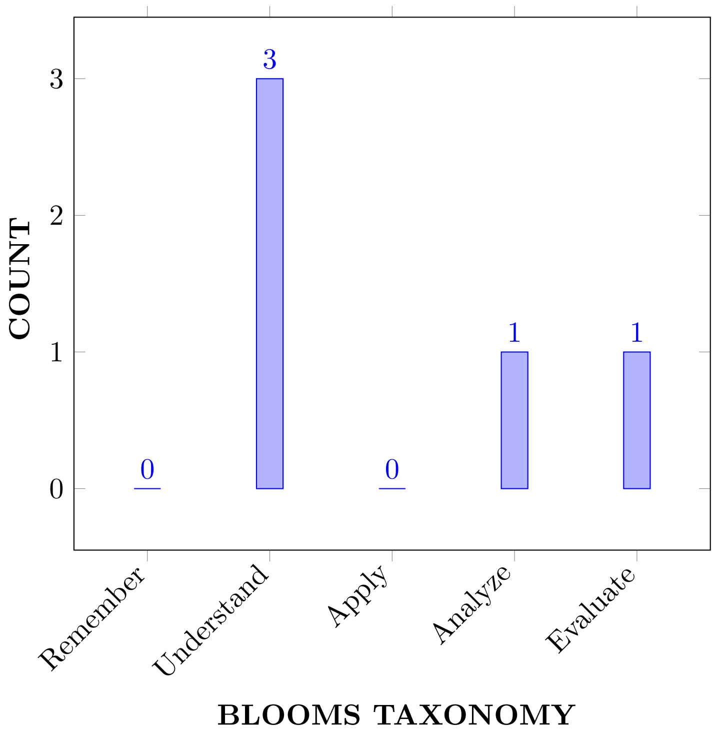
I	Simulate transmission lines using PSCAD software to analyze faults in transmission system.
II	Demonstrate load flow studies using static load flow methods using MATLAB.
III	Analyze transient state stability in power systems

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Demonstrate** the programming concepts of simulation tools for obtaining parameters of a typical transmission line and modelling	Understand
CO 2	**Illustrate** the formation of bus admittance matrices by adding one element at a time for load flow studies	Understand
CO 3	**Interpret** the symmetrical and unsymmetrical faults for transmission linesusing digital simulation	Understand
CO 4	**Evaluate** the transient response using numerical methods in RLC circuit and infinite bus systems	Evaluate
CO 5	**Analyze** the transformer inrush current for unbalanced three phase parameters	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises

PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	CIA
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises
PO 10	**Communication:** Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	2	Day -to- Day evaluation sheets

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization	2	Lab Exercises
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development	2	Lab Exercises
PSO 3	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Observe the functionality **(knowledge)** of parameters of a typical transmission line and modelling using principles of mathematics and engineering science **principles of Mathematics and Engineering**	3
	PO 2	Understand the given power system components application **problem statement by analyzing complex engineering problems**	3
CO 2	PO 1	Illustrate the formation of bus admittance matrices using principles of mathematics and engineering science	3

	PO 10	**Communication:** Communicate effectively on**complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and **write effective reports** and **design documentation**, make **effective presentations**, and give and receive clear instructions	2
CO 3	PO 1	Apply **(knowledge)** the symmetrical and unsymmetrical faultsby using the **principles of mathematics, engineering science.**	3
	PO 2	Understand the given the symmetrical and unsymmetrical faultsby **analyzing complex engineering problems**	3
	PO 10	**Communication:** Communicate effectively on**complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and **write effective reports** and **design documentation**, make **effective presentations**, and give and receive clear instructions	3
CO 4	PO 1	Understand the transient response for RLC circuit using**principles of mathematics and engineering science**	3
	PO 2	Illustrate the transient response for RLC circuit by **analyzing complex engineering problems**	3
CO 5	PO 2	Formulate and Evaluate the unbalanced three phase parameter**Topologies for Energy Conversion**	3
	PO 10	**Communication:** Communicate effectively on**complex Engineering activities** with the Engineering community and with society at large, such as, being able to comprehend and **write effective reports** and **design documentation**, make **effective presentations**, and give and receive clear instructions	2
	PSO 3	Formulate and Evaluate the unbalanced three phase parameter **Topologies for Energy Conversion**	3

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES			PSO'S
	PO 1	PO 3	PO 5	PSO 3
CO 1	2	3		3
CO 2	2		2	3
CO 3	2	3		3
CO 4	2		2	3
CO 5	2	3	2	3

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**FORMATION OF BUS ADMITTANCE AND IMPEDANCE MATRICES**
	Formation of bus admittance matrices by adding one element at a time and also write a program for Zbus building algorithm using MATLAB.
WEEK II	**LOAD FLOW SOLUTION USING GAUSS SEIDEL METHOD**
	Write a MATLAB program for load flow studies without and with generator buses using Gauss Seidel Method.
WEEK III	**LOAD FLOW SOLUTION USING NEWTON RAPHSON AND FDLF METHOD**
	Write a MATLAB program for load flow studies using Newton Raphson and Fast Decoupled Load Flow (FDLF) method.
WEEK IV	**POWER SYSTEM FAULT ANALYSIS**
	Analysis of symmetrical and unsymmetrical faults using symmetrical components using MATLAB.
WEEK V	**POINT BY POINT METHOD**
	Development of MATLAB program for Transient stability analysis of single machine infinite bus and multi machine system by point by point method.
WEEK VI	**TRANSIENT RESPONSE OF RLC CIRCUIT**
	Obtain transient response of RLC circuit using PSCAD.
WEEK VII	**THREE PHASE SHORT CIRCUIT ANALYSIS IN A SYNCHRONOUS MACHINE**
	Analyze symmetrical faults and short circuit studies in a given synchronous machine using PSCAD.
WEEK VIII	**STUDY OF TRANSMISSION SYSTEM AND SHORT CIRCUIT ANALYSIS OF 9 BUS SYSTEM**
	Study of simple transmission system and also Perform short circuit analysis on IEEE 9 bus system using PSCAD.
WEEK IX	**TRANSFORMER INRUSH CURRENT**

	Determination of transformer inrush current under unbalanced three phase parameters using PSCAD.
WEEK X	**SMALL SIGNAL STABILITY ANALYSIS**
	Development of PSCAD Model for stability analysis of single machine-infinite bus with STATCOM.
WEEK XI	**TRANSMISSION LINE PARAMETERS**
	Obtaining parameters of a typical transmission line and modelling it in PSCAD.
WEEK XII	**LOAD FREQUENCY CONTROL**
WEEK XIII	Obtain the frequency response of single and two area power system using PSCAD **POWER QUALITY**
	Familiarization with PSCAD and Understanding of Reactive power and power factor correction in AC circuits. Current harmonics drawn by power electronics interface.
WEEK XIV	**DISTANCE PROTECTION**
	Development of PSCAD model to study the distance protection scheme in long transmission line

TEXTBOOKS

1. M D Singh, K B Kanchandhani, "Power Electronics", Tata Mc Graw Hill Publishing Company, 2nd Edition, 1998.
2. Dr. P S Bimbhra, "Power Electronics", Khanna Publishers, 5th Edition, 2012.
3. Ned Mohan, Tore M Undeland, William P Robbins, "Power Electronics: Converters, Applications and Design", 3rd Edition, John Wiley and sons, 2002.
4. M H Rashid, "Power Electronics, Circuits, Devices and Applications", Pearson, 3rd Edition, 2001.

REFERENCE BOOKS:

1. Vedam Subramanyam, "Power Electronics", New Age International Limited, 2nd Edition, 2006.
2. P C Sen, "Power Electronics", Tata McGraw-Hill Publishing, 1st Edition, 1987.
3. G K Dubey, S R Doradra, A Joshi, R M K Sinha, "Thyristorised Power Controllers", New Age International Limited, 2nd Edition, 2008.
4. V R Moorthi, "Power Electronics Devices", Oxford University Press, 4th Edition, 2005.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Formation of bus admittance matrices by adding one element at a time and also write a program for Zbus building algorithm using MATLAB.	CO 1	R1: 1.2
2	Write a MATLAB program for load flow studies without and with generator buses using Gauss Seidel Method.	CO 2	R2: 3.5

3	Write a MATLAB program for load flow studies using Newton Raphson and Fast Decoupled Load Flow (FDLF) method.	CO 3	R1: 3.4
4	Analysis of symmetrical and unsymmetrical faults using symmetrical components using MATLAB.	CO 4	R1: 2.2
5	Development of MATLAB program for Transient stability analysis of single machine infinite bus and multi machine system by point by point method	CO 5	R1: 2.4
6	Obtain transient response of RLC circuit using PSCAD.	CO 2	R3: 4.5
7	Analyze symmetrical faults and short circuit studies in a given synchronous machine using PSCAD.	CO 5	R3: 4.6
8	Study of simple transmission system and also Perform short circuit analysis on IEEE 9 bus system using PSCAD.	CO 5	R2: 5.1
9	Determination of transformer inrush current under unbalanced three phase parameters using PSCAD.	CO 5	R2: 5.2
10	Development of PSCAD Model for stability analysis of single machine-infinite bus with STATCOM.	CO 1	R1: 7.1
11	Obtaining parameters of a typical transmission line and modelling it in PSCAD.	CO 2	R1:7.2
12	Obtain the frequency response of single and two area power system using PSCAD	CO 4	R1:7.3
13	Familiarization with PSCAD and Understanding of Reactive power and power factor correction in AC circuits. Current harmonics drawn by power electronics interface.	CO 4	R1:7.2
14	Development of PSCAD model to study the distance protection scheme in long transmission line.	CO 3	R1:7.3

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Numerical relays:** Design numerical relays using MATLAB and PSCAD
2	**Renewable energy conversion:** Design of transmission lines used in renewable energy conversion with simulation software

Signature of Course Coordinator **HOD,EEE**
Mr. A Naresh Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTION

Course Title	**EMBEDDED SYSTEMS DESIGN AND PROGRAMMING**				
Course Code	AEC024				
Program	B.Tech				
Semester	EIGHT				
Course Type	Core				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	-	3	-	-
Chief Coordinator	Ms. M Suguna Sri, Assistant Professor.				

I. COURSE OVERVIEW:

This course allows students to learn the fundamentals of embedded system hardware and firmware design. It focuses on embedded system design process, embedded C, interfacing modules, software development tools for debugging and testing of embedded applications, ARM & SHARC processor architectures and memory organization. It provides hands-on experience on implementation of embedded application prototype design using embedded C.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEC010	V	Computer Organization
B.Tech	AEC013	VI	Microprocessors and Microcontrollers

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Embedded Systems design and programming	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✔	Power Point Presentation		Chalk & Talk	✔	Assignments	✗	MOOCs
✗	Open Ended Experiments	✔	Seminars	✔	Project	✔	Videos
✗	Others						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for SEE. Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into five units and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows: Two full questions with “either‟ or ‟choice” are drawn from each unit of the syllabus. Each question carries 14 marks. **There could be a maximum of two sub divisions in a question.**

The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1.

Table 1: The expected percentage of cognitive level of questions in SEE.

Percentage of Cognitive Level	Blooms Taxonomy Level
0 %	Remember
50 %	Understand
25 %	Apply
20 %	Analyze
5 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 2), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (Table 3).

Table 2: Assessment pattern for CIA

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams

Quiz –Online Examination:

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT):

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table 3**.**

Table 3: Assessment pattern for AAT

5 Minutes Video	Assignment	Tech-talk	Seminar	Open Ended Experiment
20%	30%	30%	10%	10%

VI. COURSE OBJECTIVES:

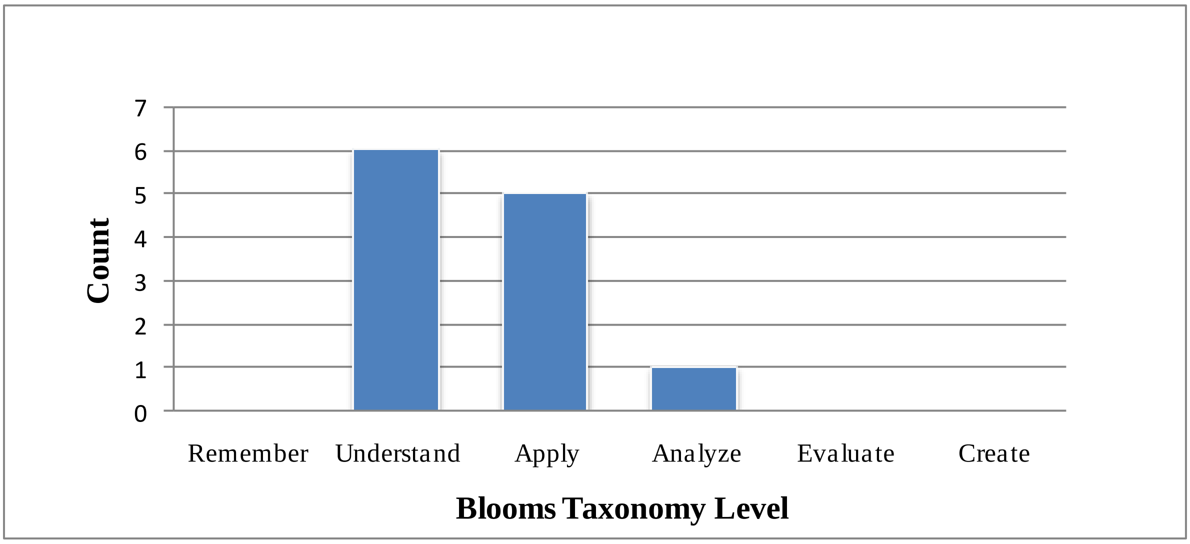
The students will try to learn:	
I	The fundamental concepts of embedded computing, embedded C, RTOS and embedded software tools for implementing embedded systems.
II	Embedded software development tools for debugging and testing of embedded applications, architectures of ARM and SHARC processors.
III	Interfacing with external environments using sensors, actuators and communication in distributed embedded systems.

VII. COURSE OUTCOMES:

After successful completion of the course, students will be able to:		
	Course Outcomes	**Knowledge Level (Bloom's Taxonomy)**
CO 1	**Illustrate** the concepts of embedded systems using their architectures.	Understand
CO 2	**Summarize** the hardware functionality of embedded system for rapid design and programming embedded systems.	Understand
CO 3	**Apply** the integration of sensors, actuators and on-chip peripherals of microcontroller architectures for prototype design.	Apply
CO 4	**Demonstrate** the principles of RTOS such as interrupt latency and context switching in hard real time environments.	Understand

CO 5	**Make use of** embedded software development tools for debugging and testing of embedded applications.	Apply
CO 6	**Demonstrate** the multiprocessing and multitasking in real time operating system for estimating the performance of embedded system.	Understand
CO 7	**Analyze** the task communication and task synchronization for implementation of real-time operating systems.	Analyze
CO 8	**Build** time constrained embedded systems using the concepts of real time operating systems.	Apply
CO 9	**Illustrate** the architecture, memory management, instruction level parallelism and application development using ARM and SHARC processors.	Understand
CO 10	**Model** a embedded application prototype using embedded C.	Apply
CO 11	**Construct** the time constrained application alone or as a member of a small group to meet design specifications.	Apply
CO 12	**Understand** the concepts of Internet of Things for building the embedded systems applications.	Understand

COURSE KNOWLEDGE COMPETENCY LEVELS



VIII. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	CIE/Quiz/AAT
PO 3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and	3	CIE/Quiz/AAT

Program Outcomes		Strength	Proficiency Assessed by
	safety, and the cultural, societal, and environmental considerations.		
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	AAT
PO 5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	3	AAT
PO 9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Seminars and Projects
PO 12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	Seminars

3 = High; 2 = Medium; 1 = Low

IX. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency assessed by
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.	-	-
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development	-	-
PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer.	1	AAT

3 = High; 2 = Medium; 1 = Low

X. MAPPING OF EACH CO WITH PO(s), PSO(s):

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	√	√	√	√	√	-	-	-	√	-	-	-	-	-	√

CO 4	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	√	√	√	√	√	-	-	-	-	-	-	-	-	-	-
CO 6	√	√	√	√	√	-	-	-	-	-	-	-	-	-	-
CO 7	√	√	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 8	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 9	√	-	-	-	-	-	-	-	-	-	-	√	-	-	-
CO 10	√	√	√	√	√	-	-	-	-	-	-	-	-	-	-
CO 11	√	√	√	√	√	-	-	-	-	-	-	√	-	-	-
CO 12	√	√	√	-	√	-	-	-	√	-	-	-	-	-	-

XI. JUSTIFICATIONS FOR CO-PO MAPPING:

Course Outcomes	POs / PSOs	Justification for Mapping (Students will be able to)	No. of key competencies
CO 1	**PO 1**	Illustrate the concepts **(knowledge)** of embedded systems using their architectures by **using mathematics, science, engineering fundamentals to the solution of complex engineering problems.**	3
CO 2	**PO 1**	Understand the hardware functionality of embedded system by **using science and engineering fundamentals** specialization to the solution of complex engineering problems.	2
CO 3	**PO 1**	**Apply** the integration of sensors, actuators and on-chip peripherals of microcontroller architectures for prototype design by **applying engineering fundamentals.**	1
	PO 2	Understand the given the embedded application **problem statement** and finding the **solution implementation** of prototype embedded system design by **analyzing complex engineering problems**.	4
	PO 3	Design solutions for **complex Engineering problems** and **design system components** of **embedded applications** that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations.	2
	PO4	Use research-based **knowledge** and **research methods** including design of experiments, analysis and interpretation of data, and synthesis of the information of the basic embedded modules using different electronic circuits to provide valid conclusions.	6
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering tools including prediction and modelling the embedded circuits using **Keil integrated development environment tool** to complex Engineering activities with an understanding of the limitations.	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams **in the design of projects**, and in multidisciplinary settings.	4

Course Outcomes	POs / PSOs	Justification for Mapping (Students will be able to)	No. of key competencies
	PSO 3	Make use of sensors, actuators and on-chip peripherals process controllers **for entry level position to meet the requirements of the employer.**	1
CO 4	**PO 1**	Demonstrate **(knowledge)** the principles of RTOS such as interrupt latency and context switching in hard real time environments by **applying the knowledge of science, engineering fundamentals**, and an engineering specialization to the solution of complex engineering problems.	2
CO 5	**PO 1**	Make use of embedded software development tools (knowledge) for debugging and testing of embedded applications to the solution of complex engineering problems **using mathematics, science, engineering fundamentals**.	3
	PO 2	Understand the given the embedded application **problem statement** and finding the **solution implementation** of embedded applications using tools by **analyzing complex engineering problems.**	3
	PO 3	Design solutions for **complex Engineering problems** and **design system components** of **embedded applications** that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations.	5
	PO 4	Use research-based **knowledge** and **research methods** including design of experiments, analysis and interpretation of data, and synthesis of the information of the embedded software development tools to provide valid conclusions.	6
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering tools including prediction and modelling the embedded circuits using **Keil integrated development environment tool** to complex Engineering activities with an understanding of the limitations.	1
CO 6	**PO 1**	Demonstrate **(knowledge)** the multiprocessing and multitasking in real time operating system for estimating the performance of embedded system by **applying engineering fundamentals**, and an engineering specialization to the solution of complex engineering problems.	1
	PO 2	Understand the **problem statement** of multiprocessing & multitasking and finding the **solution implementation** of embedded applications by **analyzing complex engineering problems.**	3
	PO 3	Design solutions of estimating the performance of embedded systems for **complex Engineering problems** that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	6
	PO 4	Use research-based **knowledge** and **research methods** including design of experiments, analysis and interpretation of data, and synthesis of the information of the multiprocessing and multitasking in global engineering applications to provide valid conclusions	7

Course Outcomes	POs / PSOs	Justification for Mapping (Students will be able to)	No. of key competencies
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering tools including prediction and modelling the embedded circuits using **Keil integrated development environment tool** to complex Engineering activities with an understanding of the limitations.	1
CO 7	**PO 1**	Understand **(knowledge)** the task communication and task synchronization for implementation of real-time operating systems by applying **engineering fundamentals** to the solution of complex engineering problems.	1
	PO 2	Understand the **problem statement** of real-time operating systems and finding the **solution implementation** of embedded applications by **analyzing complex engineering problems.**	3
CO 8	**PO 1**	Build the time constrained embedded systems using the concepts of real time operating systems by **applying mathematics and engineering fundamentals** to the solution of complex engineering problems.	2
CO 9	**PO 1**	Understand (knowledge) the architecture, memory management and application development using ARM and SHARC processors by applying **engineering fundamentals**	1
	PO 12	Recognize the need for application development using ARM processor using and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change **by beginning work on advanced degree**.	2
CO 10	**PO 1**	**Implement** embedded application prototype using embedded C by applying engineering fundamentals.	1
	PO 2	Understand the **problem statement** of embedded prototype design in global engineering applications in **complex problem analysis using mathematics**.	3
	PO 3	Design solutions of embedded applications in global engineering applications for **complex Engineering problems** that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations.	6
	PO 4	Use research-based **knowledge** and **research methods** including design of experiments, analysis and interpretation of data, and synthesis of the information of the embedded prototype design in global engineering applications to provide valid conclusions.	6
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering tools including prediction and modelling the embedded circuits using **Keil integrated development environment tool** to complex Engineering activities with an understanding of the limitations.	1
CO 11	**PO 1**	Understand **(knowledge)** the time constrained application alone or as a member of a small group to meet design specifications by **applying engineering fundamentals**.	1
	PO 2	Understand the **problem statement** of time constrained application in global engineering applications in **complex problem analysis using mathematics**.	3
	PO 3	Design solutions of time constrained applications in global engineering applications for **complex Engineering problems**	6

Course Outcomes	POs / PSOs	Justification for Mapping (Students will be able to)	No. of key competencies
		that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations.	
	PO 4	Use research-based **knowledge** and **research methods** including design of experiments, analysis and interpretation of data, and synthesis of the information of the embedded systems in global engineering applications to provide valid conclusions.	6
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering tools including prediction and modelling the embedded circuits using **Keil integrated development environment tool** to complex Engineering activities with an understanding of the limitations.	1
	PO 12	Recognize the need for embedded application and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change **by beginning work on advanced degree**.	2
CO 12	**PO 1**	Understand (knowledge) the concepts of Internet of Things for building the embedded systems applications by **applying science and engineering fundamentals.**	2
	PO 2	Understand the **problem statement** of Internet of Things (I.O.T) based embedded applications in global engineering applications for **complex problem analysis using mathematics**.	3
	PO 3	Design solutions of embedded applications in global engineering applications for **complex Engineering problems** that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations.	5
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering tools including prediction and modelling the embedded circuits using **Keil integrated development environment tool** to complex Engineering activities with an understanding of the limitations.	1
	PO 9	**Understand** the interfacing of Internet of Things with embedded systems by applying **engineering fundamentals.**	1

XII. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING

Course Outcomes	Program Outcomes / No. of key competencies matched												PSOs/ Number of key competencies		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	1	4	2	6	1	-	-	-	4	-	-	-	-	-	1

CO 4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	3	5	6	1	-	-	-	-	-	-	-	-	-	-
CO 6	1	3	6	7	1	-	-	-	-	-	-	-	-	-	-
CO 7	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 8	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 9	1	-	-	-	-	-	-	-	-	-	-	2	-	-	-
CO 10	1	3	6	6	1	-	-	-	-	-	-	-	-	-	-
CO 11	1	3	6	6	1	-	-	-	-	-	-	2	-	-	-
CO 12	2	3	5	-	1	-	-	-	1	-	-	-	-	-	-

XIII. PERCENTAGE OF KEY COMPETENCIES FOR CO-(PO/PSO):

Course Outcomes	**Program Outcomes / No. of key competencies**												**PSOs/ No. of key competencies**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
	3	**10**	**10**	**11**	**1**	**5**	**3**	**3**	**12**	**5**	**12**	**12**	**2**	**2**	**2**
CO 1	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 2	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 3	100.0	40.0	20.0	54.5	100.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0	50.0
CO 4	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 5	100.0	30.0	50.0	54.5	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 6	33.3	30.0	60.0	70.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 7	33.3	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 8	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 9	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0
CO 10	33.3	30.0	60.0	54.5	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 11	33.3	30.0	60.0	54.5	100.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0
CO 12	66.7	30.0	50.0	0.0	100.0	0.0	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	0.0

XIV. COURSE ARTICULATION MATRIX (CO-PO/PSO MAPPING)

COs and Pos and COs and PSOs on the scale of 0 to 3, **0** being **no correlation**, **1** being the **low correlation**, **2** being **medium correlation** and **3** being **high correlation**.

0 – $0 \leq C \leq 5\%$–No correlation **2** – 40 % $< C <$ 60% –Moderate

1 – $5 < C \leq 40\%$– Low/ Slight **3** – $60\% \leq C < 100\%$ – Substantial /High

Course Outcomes	**Program Outcomes**												**Program Specific Outcomes**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO 1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO 2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO 3	3	1	1	2	3	0	0	0	1	0	0	0	0	0	1
CO 4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO 5	3	0	2	2	3	0	0	0	0	0	0	0	0	0	0
CO 6	1	1	3	3	3	0	0	0	0	0	0	0	0	0	0
CO 7	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CO 8	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO 9	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
CO 10	1	1	3	2	3	0	0	0	0	0	0	0	0	0	0
CO 11	1	1	3	2	3	0	0	0	0	0	0	1	0	0	0
CO 12	3	1	2	0	3	0	0	0	1	0	0	0	0	0	0
TOTAL	26	6	14	11	18	0	0	0	2	0	0	2	0	0	1
AVERAGE	**2.16**	**1**	**2.33**	**2.20**	**3**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**1**

XV. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO 1, PO 2	SEE Exams	PO 1, PO 2, PO 5	Assignments	PO 1, PO 2, PO 5	Seminars	PO 1, PO 12
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO 4, PO 5						

XVI. ASSESSMENT METHODOLOGIES - INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XVII. SYLLABUS

MODULE-I	EMBEDDED COMPUTING

Definition of embedded system, embedded systems vs. general computing systems, history of embedded systems, complex systems and microprocessor, classification, major application areas, the embedded system design process, characteristics and quality attributes of embedded systems, formalisms for system design, design examples.

MODULE-II	PROGRAMMING EMBEDDED SYSTEMS IN C

Embedded systems programming in C, binding and running embedded C program in Keil IDE, building the hardware; The Project Header (MAIN.H), The Port Header (PORT.H), Example: Restructuring the “Hello Embedded World‟ example.

MODULE-III	EMBEDDED C APPLICATIONS

Basic techniques for reading from port pins, Example: Reading and writing bytes, Example: Reading and writing bits (simple version), Example: Reading and writing bits (generic version).
Basic techniques for reading and writing from I/O port pins, LED interfacing, interfacing with keyboards, displays, Stepper motor interfacing.

MODULE-IV	INTRODUCTION TO REAL-TIME OPERATING SYSTEMS

Tasks and Task States, Semaphores, and Shared Data; Message Queues, Mailboxes and Pipes, Timer Functions, Events, Semaphores and Queues, Hard Real-Time Scheduling Considerations, Interrupt Routines in an RTOS Environment.
Embedded Software Development Tools: Host and Target machines, Linker/Locators for Embedded Software, Getting Embedded Software into the Target System; Debugging Techniques: Testing on Host Machine.

MODULE-V	INTRODUCTION TO ADVANCED ARCHITECTURES

ARM and SHARC, processor and memory organization and instruction level parallelism; Networked embedded systems: Bus protocols, I2C bus and CAN bus.

Text Books:

1. Shibu K.V, “Introduction to Embedded Systems”, Tata McGraw Hill Education Private Limited, 2nd Edition, 2009.
2. Raj Kamal, “Embedded Systems: Architecture, Programming and Design”, Tata McGraw-Hill Education, 2nd Edition, 2011.
3. Andrew Sloss, Dominic Symes, Wright, “ARM System Developer's Guide Designing and Optimizing System Software”, 1st Edition, 2004.

Reference Books:

1. Wayne Wolf, “Computers as Components, Principles of Embedded Computing Systems Design”, Elsevier, 2nd Edition, 2009.
2. Dr. K. V. K. K. Prasad, “ Embedded / Real-Time Systems: Concepts, Design & Programming”, Dream tech publishers, 1st Edition, 2003.
3. Frank Vahid, Tony Givargis, “Embedded System Design”, John Wiley & Sons, 3rd Edition, 2006.
4. Lyla B Das, “Embedded Systems” , Pearson Education, 1st Edition, 2012.
5. David E. Simon, “An Embedded Software Primer”, Addison-Wesley, 1st Edition, 1999.
6. Michael J.Pont, “Embedded C”, Pearson Education, 2nd Edition, 2008.

XVIII. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be Covered	COs	Reference
1-2	Definition of embedded system vs general computing system history of embedded systems.	CO 1	T1-1.1
3-4	Complex systems and microprocessor, classification, major application areas, the embedded system design process.	CO 2	T1-1.2
5-6	Analyze the Characteristics and quality attributes of embedded systems, formalisms for system design.	CO 2	T1-1.3
7	Design examples.	CO 2	T2-1.4
8-9	Explain about the C looping structures, register allocation, function calls, pointer aliasing.	CO 3	T2-1.5
10-12	Describe the Structure arrangement, bit fields, unaligned data and endianness, inline functions and inline assembly.	CO 3	R2-1.2
13-14	Identify the Portability issues; Embedded systems programming in C, binding and running embedded C program in Keil IDE.	CO 4	T3-1.3
15-16	Dissecting the program, building the hardware; Basic techniques for reading and writing from I/O port pins, switch bounce.	CO 5	T3-2.4
17-18	List the Applications: Switch bounce, LED interfacing, interfacing with keyboards, displays.	CO 4	T3-2.5
19-20	List the A/D and D/A conversions.	CO 5	T3-2.6
21-22	Multiple interrupts, serial data communication using embedded C interfacing.	CO 5	T3-2.7
23-24	Recall Operating system basics, types of operating systems, tasks and task states.	CO 6	T3-2.8
25-26	Describe the Process and threads, multiprocessing and multitasking, how to choose an RTOS, task scheduling, semaphores.	CO 7	T3-2.9
27-28	Queues, hard real-time scheduling considerations, saving memory and power. Task communication: Shared memory.	CO 8	R2-3.1
29-30	Explain about the Message passing, remote procedure call and sockets; Task synchronization.	CO 9	R2-3.2
31-32	Task communication synchronization issues, task synchronization techniques.	CO 9	R2-3.3
33-34	Explain the Device drivers.	CO 9	R2-3.4
35-36	Explain the Host and target machines.	CO 10	R2-3.5
37-38	Recall the Linker/locators for embedded software.	CO 9	R2-3.6
39-40	Getting embedded software into the target system; Debugging techniques.	CO 10	R3-3.7
41-42	Testing on host machine, using laboratory tools.	CO 10	R3-3.8
43-44	Example programs.	CO 10	R3-4.1
45-46	Example programs.	CO 10	R3-4.2
47-48	Explain about the Introduction to advanced architectures.	CO 11	R3-4.3

Lecture No	Topics to be Covered	COs	Reference
49-50	Describe about the ARM and SHARC, processor and memory organization.	CO 12	R3-4.4
51-52	Describe the Instruction level parallelism; Networked embedded systems.	CO 12	R3-4.5
53-54	List the Bus protocols, I2C bus and CAN bus.	CO 11	T2-8.1
55-56	Recognize the Internet-Enabled systems.	CO 10	T2-8.2
57-58	Design example-Elevator controller.	CO 11	T2-8.3
59-60	Example programs.	CO 11	T2-8.4

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INSTITUTE OF AERONAUTICAL ENGINEERING
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Dundigal, Hyderabad - 500 043
COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**HYBRID ELECTRIC VEHICLES**				
Course Code	AEE019				
Program	B.Tech				
Semester	VIII	EEE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms Shaik Ruksana Begam, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AEE004	III	DC Machines and Transformers
UG	AEE007	IV	AC Machines
UG	AEE013	VI	Solid State Electric Motor Drives

II COURSE OVERVIEW:

Electric and Hybrid Vehicles course deals with technical knowledge and practical expertise in commercial automobile technologies. As a part of this course, design, component selection and sizing at both system and vehicle level with a special focus on drives, battery modeling and control has been elaborated. A comprehensive overview of Electric and Hybrid Vehicles is emphasized on configuration, main issues and energy management strategies. This course also concludes with different control schemes used in motor drives and energy management systems.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
HYBRID ELECTRIC VEHICLES	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	✓	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage

in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1.

Percentage of Cognitive Level	Blooms Taxonomy Level
20%	Remember
40 %	Understand
25 %	Apply
15 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 2), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (Table 3).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Open Ended Experiment
50%	50%	-%

VI COURSE OBJECTIVES:

The students will try to learn:

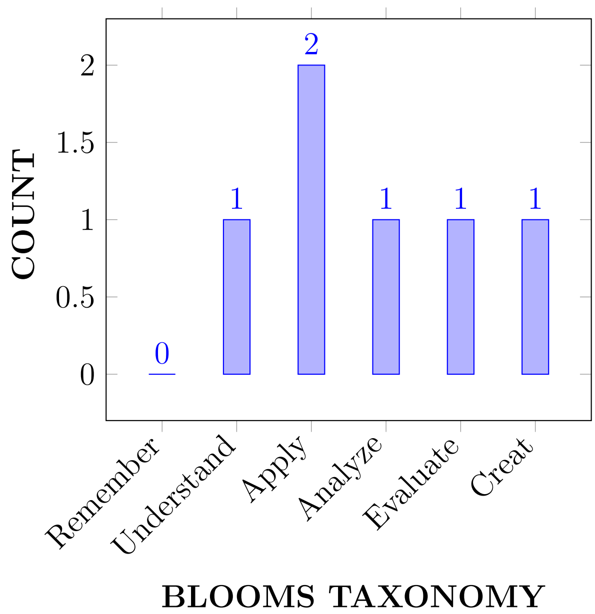
I	The concepts of modeling, design, and development of energy storage systems in hybrid electric vehicles.
II	The importance of hybrid electric vehicles to address the issues associated with environmental pollution and energy crisis.
III	The need of rapid control prototyping techniques to design and validate HEV high level and low level control system.
IV	The Know-how and aptitude towards future trends in Hybrid Electric Vehicles.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Summarize** the various topologies and modeling techniques used in electric and hybrid vehicles for performance analysis.	Understand
CO 2	**Analyze** cost-effectiveness of different types of hybrid drive-trains for transmitting power to driving wheels.	Analyze
CO 3	**Demonstrate** the configuration and control of Electric motor drives for maximizing speed and torque.	Evaluate
CO 4	**Choose** the hybridization of Energy Storage Systems for reducing size.	Apply
CO 5	**Select** suitable Energy Storage Systems and drive train components for optimizing energy management.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.	1	CIE / Quiz / AAT
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development.	3	CIE / Quiz / AAT
PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer	3	CIE / Quiz / AAT

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	✓	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-
CO 3	✓	✓	✓	-	✓	-	-	-	-	-	-	-	✓	-	✓
CO 4	✓	✓	-	-	-	-	✓	-	-	-	-	✓	-	✓	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	✓	-

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	**Apply** hybrid electric vehicles concepts in **Engineering knowledge, understanding and applications.**	1
	PO 2	Problem Analysis of hybrid electric vehicle concepts by identification, and system definition.	4
	PO 7	Understand the impact of the social and Environmental impacts of Hybrid and Electric vehicles for Environment and sustainability	2
CO 2	PO 1	Apply the impact of modern drive-trains on Engineering knowledge, understanding and applications	4
	PO 2	Problem Analysis of modern drive-trains by identification, definition, formulation, information and validation for decarburization of energy supply.	1
	PSO 2	Focus on electrical drives with its converter topologies on energy conversion, management and auditing in specific applications.	1

CO 3	PO 1	Apply modeling techniques in hybrid electric vehicles for Engineering knowledge, understanding and applications.	1
	PO 2	Problem Analysis for modeling and performing analysis in hybrid electric vehicles by problem identification, system definition, formulation, data collection, model translation and validation	1
	PO 3	Design Solution for modeling and performance analysis of electric vehicles by defining problem, understand user needs, identify cost drivers, manage design process and evaluate outcomes	1
	PO 5	Use of MATLAB software in modeling and simulation of hybrid electric vehicles.	1
	PSO 1	Simulate and/or fabricate/commission the electrical systems involving utilization of electrical energy.	1
	PSO 3	Gain the hands-on competency skills in use of computing tools necessary for entry level position to meet the requirements.	1
CO 4	PO 1	Develop electric drive-trains in hybrid electric vehicles for Engineering knowledge, understanding and applications.	1
	PO 2	Problem Analysis in identifying electric drive-trains by problem identification, system definition, formulation.	1
	PO 7	Understand the impact of Fuel efficiency for Hybrid storage systems in social and environmental contexts, and need for sustainable development.	2
	PSO 2	Focus on the components of electrical drives with its converter topologies for energy management and auditing in transmitting power to driving wheels.	2
CO 5	PO 1	Develop electric drive-trains in hybrid electric vehicles for Engineering knowledge, understanding and applications.	1
	PO 2	Problem Analysisin identifying electric drive-trains by problem identification, system definition, formulation.	6
	PSO 1	Analyze vehicle load force for sizing drive system in utilization of electrical energy.	1
	PSO 2	Focus on the components of electrical drives with its converter topologies for energy management and auditing for fuel efficiency.	2

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	2	-	-	-	-	3	-	-	-	-		-	-	-
CO 2	1	5	-	-	-	-	-	-	-	-	-	-	-	2	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 3	1	6	4	-	1	-	-	-	-	-	-	-	1	-	1
CO 4	1	3	-	-	-	-	3	-	-	-	-	2	-	2	-
CO 5	1	3	-	-	-	-	-	-	-	-	-	2	-	2	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	33	20	-	-	-	-	30	-	-	-	-		-	-	-
CO 2	33	50	-	-	-	-	-	-	-	-	-	-	-	100	-
CO 3	33	60	40	-	100	-	-	-	-	-	-	-	16	-	-
CO 4	33	30	-	-	100	-	30	-	-	-	-	20	-	100	-
CO 5	33	30	-	-	-	-	-	-	-	-	-	20	-	100	-

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - 0$\leq$ C$\leq$ 5% – No correlation

2 - 40 % <C < 60% –Moderate

1-5 <C$\leq$ 40% – Low/ Slight

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	1	-	-	-	-	3	-	-	-	-		-	-	-
CO 2	1	2	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 3	1	3	2	-	3	-	-	-	-	-	-	-	1	-	3
CO 4	1	1	-	-	3	-	3	-	-	-	-	2	-	3	-
CO 5	1	1	-	-	-	-	-	-	-	-	-	2	-	3	-
TOTAL	13	18	4	-	6	-	6	-	-	-	-	4	4	21	6
AVERAGE	1.2	1.6	2	-	3	-	3	-	-	-	-	2	1	3	3

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	
Laboratory Practices		Student Viva		Certification	
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	
Assignments	✓				

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVII SYLLABUS:

MODULE I	**INTRODUCTION**
	Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental impact hybrid and electric vehicles, impact of modern drive-trains on energy supplies; Conventional Vehicles: Basics of performance, vehicle power source characterization, transmission characteristics, and mathematical models to vehicle performance.
MODULE II	**HYBRID ELECTRIC DRIVE TRAINS**
	Hybrid Electric Drive trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive train topologies, fuel efficiency analysis; Electric Drive trains: Basic concept of electric traction, introduction to various electric drive train topologies, power flow control in electric drive train topologies, fuel efficiency analysis.
MODULE III	**ELECTRIC MOTORS FOR HYBRID ELECTRIC VEHICLES**
	Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, configuration and control of DC motor drives, configuration and control of Induction Motor drives. Configuration and control of permanent magnet motor drives, configuration and control of switch reluctance motor drives, drive system efficiency.
MODULE IV	**ENERGY STORAGE**
	Energy Storage: Introduction to energy storage requirements in hybrid and electric vehicles, Battery based energy storage and its analysis, fuel cell based energy storage and its analysis, super capacitor based energy storage and its analysis, flywheel based energy storage and its analysis, hybridization of different energy storage devices; sizing the drive system: matching the electric machine and the internal combustion engine (ICE), sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, communications, supporting subsystems.
MODULE V	**ENERGY MANAGEMENT STRATEGIES**
	Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

TEXTBOOKS

1. Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2ndEdition,2003.
2. James Larminie, John Lowry, "Electric Vehicle Technology", Wiley publications, 1stEdition,2003.
3. Mehrdad Ehsani, YimiGao, Sebastian E Gay, Ali Emadi," Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals Theory and Design", CRC Press, 2ndEdition,2004.

REFERENCE BOOKS:

1. B D McNicol, D A J Rand, “Power Sources for Electric Vehicles”, Elsevier publications, 1 stEdition,1998.
2. Seth Leitman, “Build Your Own Electric Vehicle” McGraw-Hill, 1 stEdition,2013.
3. Jeffrey Gonder, Tony Markel, “Energy Management Strategies for Plug-In Hybrid Electric Vehicles”, 2007-01- 0290, National Renewable Energy Laboratory

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO’s	Reference T1: 4.1
OBE DISCUSSION			
1	Course Objectives, Course Outcomes, CO-PO Mapping, Blooms Taxonomy, CO Articulation Matrix		
CONTENT DELIVERY (THEORY)			
1	Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental import hybrid and electric vehicles.	CO1	T1: 1.1, 1.2
2	impact of modern drive-trains on energy supplies	CO2	T1: 1.2
3	Conventional Vehicles: Basics of performance, vehicle power source characterization	CO1	T1: 1.2
4	Transmission characteristics	CO1	T1: 1.3
5	Mathematical models to vehicle performance	CO1	T1: 3.6
6	Hybrid Electric Drive trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies	CO2	T1: 1.1
7	Power flow control in hybrid drive train topologies, fuel efficiency analysis	CO2	T1: 1.1, T1: 3.8
8	Electric Drive trains: Basic concept of electric traction, introduction to various electric drive train topologies	CO2	T1: 4.2,4.3
9	Power flow control in electric drive train topologies	CO3	T1: 4.2,4.3 T2:26.10
10	Fuel efficiency analysis	CO3	T1: 4.4
11	Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles	CO3	R2: 4.7
12	Configuration and control of DC motor drives	CO3	T1: 4.9
13	Configuration and control of Induction Motor drives	CO3	T1: 4.9
14	Configuration and control of permanent magnet motor drives	CO3	T1: 5.1,5.4
15	Configuration and control of switch reluctance motor drives	CO3	T1: 5
16	Drive system efficiency	CO3	T1: 5.1
17	Energy Storage: Introduction to energy storage requirements in hybrid and electric vehicles	CO4	T1: 6.1,6.4,6.5
18	Battery based energy storage and its analysis, fuel cell based energy storage and its analysis	CO4	T1: 6.1

19	Super capacitor based energy storage and its analysis, flywheel based energy storage and its analysis	CO4	T1: 6.1
20	Hybridization of different energy storage devices;	C04	T1: 6.9, 6.10, 6.11
21	Sizing the drive system: matching the electric machine and the internal combustion engine (ICE),	CO3	T1: 6.13
22	Sizing the propulsion motor, sizing the power electronics	CO3	R1: 6.14
23	Selecting the energy storage technology	CO4	T1 : 9
24	Communications, supporting subsystems	CO5	T1: 9.5
25	Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles	CO5	R2: 9.6 R3: 1.5, 1.9
26	Classification of different energy management strategies	CO5	T1: 9.1 R3: 2.6
27	Comparison of different energy management strategies	CO5	T1: 9.1 R3: 4.3, 4.8
28	Management strategies	CO5	R1: 9.9 R3:5.8, 5.11
29	Implementation issues of energy management strategies	CO5	T1 : 9.1
30	Implementation issues of energy management strategies	CO5	T1 : 9.1
PROBLEM SOLVING/ CASE STUDIES			
1	Mathematical models to describe vehicle performance	CO 1	R2:7.5
2	Fuel efficiency analysis in hybrid drive trains	CO 2	R2:7.5
3	Fuel efficiency analysis in electric drive trains	CO2	T1 : 9
4	Drive system efficiency	CO 3	R2:7.5
5	Battery based energy storage system analysis	CO 4	T1: 6.1,6.4,6.5
6	Fuel cell based energy storage system analysis	CO 4	T1: 6.13
7	Super capacitor based energy storage system analysis	CO 4	T1 : 9
8	Flywheel based energy storage system analysis	CO 4	T1: 6.1,6.4,6.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Define Hybrid Electric Vehicles?	CO 1	T1: 9.5
2	What is Electric Vehicles?	CO 1	R4:2.1
3	Define Conventional Vehicles?	CO 1	T1: 9.5
4	What is Hybrid Electric Drive Train?	CO 2	R4:2.1
5	Define Hybrid Traction?	CO 2	T1 : 9
6	What are hybrid drivetrain topologies	CO 2	T1: 9.5
7	Define Electric Propulsion system	CO 3	R4:2.1
8	What is an Induction motor?	CO 3	R4:2.1
9	What is the principle of induction motor?	CO 3	R4:2.1
10	What is meant by regenerative braking?	CO 3	R4:2.1
11	How does a permanent magnet motor work?	CO 3	R2: 9.6
12	What is Electric Battery	CO 4	R4:2.1

13	Define Super Capacitor?	CO 4	R2: 9.6
14	What is the principle of lithium ion battery?	CO 4	R2: 9.6
DISCUSSION OF QUESTION BANK			
1	Mathematical models to vehicle performance	CO 1	R4:2.1
2	Hybrid Electric Drive trains	CO 2	T4:7.3
3	Induction motor	CO 3	R4:5.1
4	Electric Battery	CO 4	T1:7.5
5	Energy management	CO 5	T1: 4.1

Signature of Course Coordinator **HOD,EEE**
Ms. Shaik Ruksana Begam Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Flexible Alternating Currrent Transmission Systems**				
Course Code	AEE524				
Program	B.Tech				
Semester	VIII				
Course Type	Professional Elective				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. T Ravi Babu				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE010	V	Power Electronics
B.Tech	AEE012	VI	Power System Analysis

II COURSE OVERVIEW:

This course deals with the principle, operation and applications in power systems with respect to active/reactive power control. It also elaborates the issues with power quality on utility side and proposes the compensation/mitigation techniques in transmission systems. This course also concludes with multilevel switching coordination among FACTS controllers.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Flexible Alternating Currrent Transmission Systems	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	✓	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage

in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
20%	Understand
60%	Apply
20 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc.

VI COURSE OBJECTIVES:

The students will try to learn:

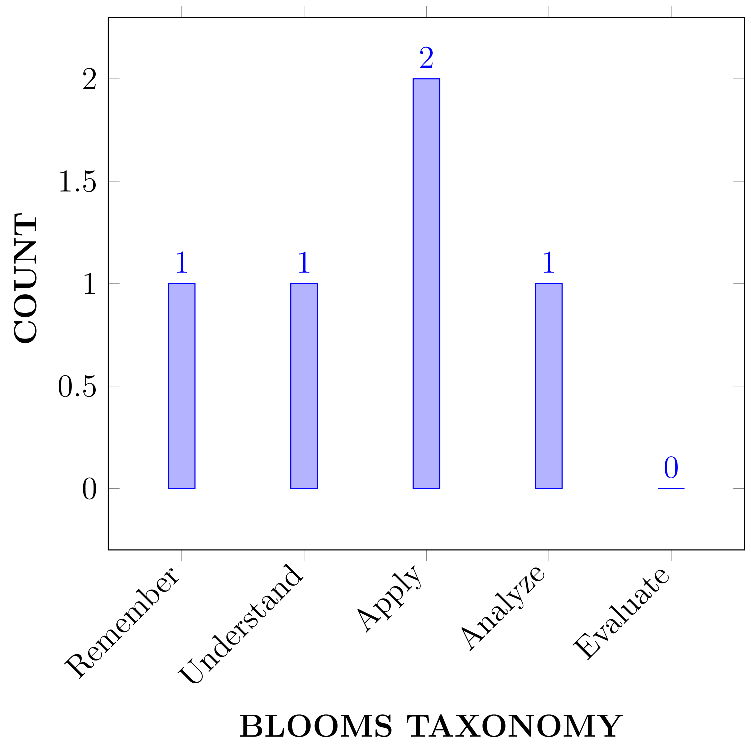
I	The concepts, types, and applications of FACTS controllers in power transmission systems
II	The need of static var compensators in regulating the voltage profile in load flow studies.
III	The various control strategies and functioning of series and shunt compensators to improve the power quality
IV	The importance of compensation and coordination of FACTS controllers in transmission systems.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Understand** the basic control of power flow and necessity of FACTS devices in power transmission network for stable operation.	Understand
CO 2	**Choose** a Static VAR Compensator for regulating the voltage thereby limiting the power oscillations in transmission systems transient stability analysis.	Remember
CO 3	**Model** the Thyristor Controlled Series Capacitor (TCSC), Gate Controlled Series Capacitor (GCSC) for load flow stability studies.	Apply
CO 4	**Examine** the various types of voltage sources converter-based FACTS controllers for load flow and transient stability analysis	Analyze
CO 5	**Develop** the coordinating schemes with the multiple FACTS controllers for reactive power compensation.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Program Outcomes	
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE / CIE / AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	SEE / CIE / AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	SEE / CIE / AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	SEE / CIE / AAT
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	SEE / CIE / AAT
PO9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	SEE / CIE / AAT
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	SEE / CIE / AAT
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	SEE / CIE / AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization	2	-
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	2	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	✓	✓	-	✓	-	-	✓	✓	-	✓	✓	✓	-
CO 2	✓	✓	✓	✓	-	✓	-	-	✓	✓	-	✓	✓	✓	-
CO 3	✓	✓	✓	✓	-	✓	-	-	✓	✓	-	✓	✓	✓	-
CO 4	✓	✓	✓	✓	-	✓	-	-	✓	✓	-	✓	✓	✓	-
CO 5	✓	✓	✓	✓	-	✓	-	-	✓	✓	-	✓	✓	✓	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Understand power flow in transmission lines for stable operation of power systems **for using principles of mathematics,science and engineering fundamentals.**	2
	PO 2	Provide power flow in transmission lines for stable operation of power systems knowledge about the real and reactive power flow in the lines in order to maximize the power transmission **using basics of mathematics and engineering sciences.**	7
	PO 3	Recall knowledge on reactive power in power systems **foranalyzing the behavior of complex electrical components**	5
	PO 4	Understand the reactance, load impedance performance of the overall electric power system **for analyzing the behavior of complex electrical components.**	6
	PO 6	Understand the inject of a voltage in the line with the facts controllers **using science and engineering fundamentals**	3
	PO 9	Understand power flow in transmission lines for stable operation of power systems **for using principles of mathematics,science and engineering fundamentals.**	4
	PO 10	Understand the importance of controllers according to thenecessities **for communicating effectively with engineering community.**	3
	PO 12	Understand power flow in transmission lines for stable operation of power systems **the need for and having the preparation and ability to engage in independent and life-long learning in the context of designing.**	4
	PSO 1	Understand the reactance, load impedance performance of the overall electric power system **s used in various stages of utilization of electrical energy.**	3
	PSO 2	Understand the importance of controllers according **to the necessities.**	7

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO 1	Demonstrate the Static VAR Compensator, its configuration **using basics engineering sciences.**	2
	PO 2	Summarize various control circuits of shunt controllers for **analyzing the behavior of complex electrical components.**	7
	PO 3	Understand Understand the shunt controllers to regulate the transmission voltage **in power systems**	5
	PO 4	Demonstrate the Static VAR Compensator Voltage Regulation **in solving complex engineering problems.**	6
	PO 6	Understand the load flow analysis of SVC to regulate transient stability **according to the necessities**	3
	PO 9	Designing of SVC in the power system, to regulate the transmission voltage **in power systems**	4
	PO 10	Understand static VAR compensator **to regulate the midpoint voltage of SMIB system**	3
	PO 12	Understand transient stability enhancement of SVC **in power systems**	4
	PSO 1	Understand power oscillation damping of single machine infinite bus system **with static VAR compensator connected at the midpoint of the line.**	3
	PSO 2	Understand load flow analysis **for modeling of static VAR compensator**	7
CO 3	PO 1	Understand the concepts Controlled Series Capacitors with the**knowledge of science and engineering fundamentals.**	2
	PO 2	Determinepower quality improvement schemes in series compemsators **for analyzing the behavior of complex electrical components.**	7
	PO 3	Demonstrate the operation, analysis and gate turn off characteristics of Thyristor Controlled Series Capacitor **using with help of engineering sciences.**	5
	PO 4	Model the TCSC and GCSC for Load flow analysis **according to the necessities.**	6
	PO 6	Recognize the importance of various operating modes of series compensator used in controlled devices **in power systems**	3
	PO 9	Focus on working as a member or leader in designing the inverter circuits **by individual and team work.**	4
	PO 10	Recognize the role of modulation techniques in outputvoltage control of GCSC **by communicating effectively with engineering community.**	3
	PO 12	Recognize the need for and having the preparation and ability to engage in independent and life-long learning **in the context of modeling of TCSC**	4
	PSO 1	Design and simulate circuits to GCSC **for stability studies**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 2	Recognize the need for and having the preparation and ability to engage in independent and life-long learning **in the context of energy conversion systems.**	7
CO 4	PO 1	Analyzethe static synchronous compensator for improving the power systems dynamics **for analyzing the behavior of complex electrical components.**	2
	PO 2	Understand Reactive Power and Voltage Control of a Transmission Line **in power system**	7
	PO 3	Analyz the encompassing capabilities of voltage regulation, series compensation, and phase shifting **in electrical components.**	5
	PO 4	Modelthe UPFC involves power flow studies which include the calculation of bulbar voltage, branch loadings, and real, reactive transmission losses according to the necessities. **according to the necessities**	6
	PO 6	Control Control both real- and reactive power flows **in a transmission**	3
	PO 9	Understand Focus on working as a member or leader in designing theStatic synchronous compensator (STATCOM).**in transmition network**	4
	PO 10	Understand power system transient stability improvement **by means of interline power flow controller (IPFC) in power systems**	3
	PO 12	Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the context of designing **the need for and having the preparation and ability to engage in independent and life-long learning in the context of designing**	4
	PSO 1	Design the converter circuits to perform AC-AC conversion to achieve desired voltage output and interpret **the results through simulation and hardware implementation.**	7
	PSO 2	Make use of the protection and commutation techniques for the circuits associated with power electronic devices**for smooth operation while energy conversion**	3
CO 5	PO 1	Understand the FACTS controller interactions with **the knowledge of science and engineering fundamentals.**	2
	PO 2	Apply the coordination of flexible alternating current transmission systems **for reactive power compensation understanding the appropriate techniques.**	7
	PO 3	Explain the concepts FACTS controller interactions**with the knowledge of mathematics, science and engineering fundamentals related basic electrical and electronics.**	5

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 4	Understand Steady-state interactions between different controllers **Steady-state interactions between different controllers**	6
	PO 6	Understand The interaction phenomena are investigated as functions of electrical coupling between the SVCs and the short-circuit level at the SVC buses. **with responsibilities relevant to the professional engineering practice**	3
	PO 9	Understand Focus on working as a member or leader in understanding Co-Ordination of Multiple Controllers using Linear – Control Techniques **individual and team work.**	4
	PO 10	Recognize Co-Ordination of multiple Controllers using Non Linear – Control Techniques **Co-Ordination of multiple Controllers using Non Linear – Control Techniques**	3
	PO 12	Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the context of optimal selection of power devices.	4
	PSO 1	Understand Electromechanical-oscillation interactions between FACTS controllers **also involve synchronous generators, compensator machines, and associated powersystem stabilizer controls**	3
	PSO 2	Outline co ordination of control techniques to **requirements of the employer**	7

Note: For Key Attributes refer **Annexure - I** and **Annexure - II** vspace-1.0cm

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	7	5	6	-	3	-	-	4	3	-	4	3	-	7
CO 2	2	7	5	6	-	3	-	-	4	3	-	4	3	-	7
CO 3	2	7	5	6	-	3	-	-	4	3	-	4	3	-	7
CO 4	2	7	5	6	-	3	-	-	4	3	-	4	3	-	7
CO 5	2	7	5	6	-	3	-	-	4	3	-	4	3	-	7

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.6	70	55	55	-	55	-	-	30	55	-	55	55	63	-
CO 2	66.6	70	55	55	-	55	-	-	30	55	-	55	55	63	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 3	66.6	70	55	55	-	55	-	-	30	55	-	55	55	63	-
CO 4	66.6	70	55	55	-	55	-	-	30	55	-	55	55	63	-
CO 5	66.6	70	55	55	-	55	-	-	30	55	-	55	55	63	-

XV COURSE ARTICULATION MATRIX (PO - PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 - $5 < C \leq 40\%$ – Low/ Slight
2 - $40\% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	2	2	-	2	-	-	1	2	-	2	2	3	-
CO 2	3	3	2	2	-	2	-	-	1	2	-	2	2	3	-
CO 3	3	3	2	2	-	2	-	-	1	2	-	2	2	3	-
CO 4	3	3	2	2	-	2	-	-	1	2	-	2	2	3	-
CO 5	3	3	2	2	-	2	-	-	1	2	-	2	2	3	-
TOTAL	**15**	**15**	**10**	**10**	**0**	**10**	**0**	**0**	**5**	**10**	**0**	**10**	**10**	**15**	**0**
AVERAGE	**3**	**3**	**2**	**2**	**0**	**2**	**0**	**0**	**1**	**2**	**0**	**2**	**2**	**3**	**0**

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Quiz	✓	Tech - Talk	-	Certification	-
Term Paper	-	Seminars	✓	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	✓	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
x	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts	-	-

XVIII SYLLABUS:

UNIT-I	**INTRODUCTION**
	FACTS Controllers: Review of basics of power transmission networks, control of power flow in AC transmission line, analysis of uncompensated AC transmission line, passive reactive power compensation, effect of series and shunt compensation at the midpoint of the line on power transfer, need for FACTS controllers, types of FACTS controllers.
UNIT-II	**STATIC VAR COMPENSATOR (SVC)**
	Static VAR compensator: Configuration of static VAR compensator, voltage regulation by static VAR compensator, modeling of static VAR compensator for load flow analysis, modeling of static VAR compensator for stability studies, design of static VAR compensator to regulate the midpoint voltage of SMIB system, applications, transient stability enhancement and power oscillation damping of single machine infinite bus system with static VAR compensator connected at the midpoint of the line.
UNIT-III	**THYRISTOR AND GTO THYRISTOR CONTROLLED SERIES CAPACITORS (TCSC and GCSC)**
	Series compensator: Concepts of controlled series compensation, operation of thyristor controlled series capacitor and gate turn off thyristor controlled series capacitor, analysis of TCSC. GCSC modeling of TCSC and GCSC for load flow studies, modeling TCSC and GCSC for stability studies, applications of TCSC and GCSC.
UNIT-IV	**VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS**
	Static synchronous compensator (STATCOM), static synchronous series compensator (SSSC), operation of STATCOM and SSSC power flow control with STATCOM and SSSC, modeling of STATCOM and SSSC for power flow and transient stability studies, operation of unified and interline power flow controllers (UPFC and IPFC) modeling of UPFC and IPFC for load flow and transient stability studies, applications.
UNIT-V	**CONTROLLERS AND THEIR COORDINATION**
	FACTS controller interactions: SVC, SVC interaction, co ordination of multiple controllers using linear control techniques, quantitative treatment of control co ordination

TEXTBOOKS

1. K R Padiyar," FACTS Controllers in Power Transmission and Distribution", New Age International (P) Ltd., Publishers, 1st Edition, 2008.

2. Narain G Hingorani, Laszio Gyugyl, "Understanding FACTS Concepts and Technology of Flexible AC Transmission System", Standard Publishers, 1st Edition, 2001

REFERENCE BOOKS:

1. K Sood, "HVDC and FACTS controllers - Applications of Static Converters in Power System", Kluwer Academic Publishers, 1st Edition, 2004.

2. Mohan Mathur, R Rajiv K Varma, "Thyristor – Based FACTS controllers for ElectricalTransmission Systems", IEEE press and John Wiley and Sons, 1st Edition, 2002.

WEB REFFERENCES

1. https://www.cet.edu.in
2. https://gndec.ac.in
3. https://www.electrical4u.com

COURSE WEB PAGE:

1. https://www.iare.ac.in/sites/default/files/Courses-description/EEE-FACTS

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Presentation on Outcome based education		
CONTENT DELIVERY (THEORY)			
2	Introduction to FACTS and Power Systems Distribution	CO 1	R1: 1.1
3	Review Of Basics of Power Transmission Networks	CO 1	T2:1.2
4	Control of power flow in AC Transmission line	CO 1	R1:1.2
5	Analysis Of Uncompensated AC Transmission Line	CO 1	T1:2.1-2.2
6	Passive Reactive Power Compensation	CO 1	T1: 2.3
7	Effect Of Series Compensation At The Midpoint Of The Line On Power Transfer	CO 1	T2: 2.3
8	Effect of shunt compensation at the midpoint of the line on power transfer	CO 1	T2: 2.4
9	Types of facts controllers.	CO 1	R1:1.6-1.7
10	Static Var Compensator: configuration of Static Var Compensator	CO 2	T2: 3.2
11	Voltage regulation by Static VAR Compensator	CO 2	T2: 3.4
12	Modeling of Static Var Compensator.	CO 2	T1:4.7.1
13	Modeling of Static Var Compensator for load flow analysis.	CO 2	T2:4.7.1
14	Modeling of Static Var Compensator for stability studies	C0 2	T2:4.7.4
15	Design of Static Var Compensator	CO 2	T2:5.2.5
16	Static Var Compensator designing to regulate the midpoint voltage of SMIB system,	CO 2	T1:5.2.5
17	Transient stability enhancement	CO 2	T1:6.3
18	Power oscillation damping of single machine infinite bus system with static var compensator connected at the midpoint of the line	CO 2	T1:6.7
19	Applications SVC	CO 2	T2:3.8
20	Series Compensator	CO 3	T1:7.1
21	Concepts of Controlled Series Compensation	CO 3	T2:4.2
22	Operation of Thyristor Controlled Series Capacitor	CO3	T2:4.3
23	Gate turn off Thyristor Controlled Series Capacitor	CO 3	T2:4.3

24	Analysis of TCSC	CO 3	T2:4.4
25	Analysis of GCSC	CO 3	T2:4.7
26	Modeling of TCSC and GCSC for load flow studies	CO 3	T2:4.8
27	Modeling TCSC and GCSC for stability studies	CO 3	T2:4.8
28	Applications of TCSC and GCSC	CO 3	T2:4.9
29	Static Synchronous Compensator (STATCOM)	CO 4	T2:6.1
30	Static Synchronous Series Compensator (SSSC)	CO 4	T2:7.1
31	Operation of STATCOM and SSSC power flow control	CO 4	T2:7.2
32	Modeling of STATCOM and SSSC for power flow	CO 4	T2:7.3
33	Modeling of STATCOM and SSSC for transient stability studies	CO 4	T2:7.3
34	Modeling of STATCOM and SSSC for transient stability studies	CO 4	T2:7.3
35	Introduction UPFC and IPFC	CO 4	T2:8.2,8.5
36	Operation of unified and interline power flow controllers	CO 4	T2:8.2,8.5
37	Modeling of UPFC and IPFC for load flow	CO 4	T2:8.7
38	Modeling of UPFC and IPFC for transient stability studies	CO 4	T2:8.7
39	Applications of UPFC and IPFC	CO 4	T2:8.9
40	FACTS controller interactions	CO 5	T1:9.2
41	FACTS controller interactions SVC	CO 5	T1:9.2
42	Coordination of multiple controllers	CO 5	T1 :9.8
43	Coordination using linear control techniques	CO 5	T1:9.8
44	Quantitative treatment of control co ordination	CO 5	T1:9.9
45	Controller Coordination for Damping Enhancement	CO 5	T1:9.9
PROBLEM SOLVING/ CASE STUDIES			
46	Problems on transmission lines and facts devices	CO 1	T3: 6.9-6.14
45	Problems on Static Var compensator	CO 2	T3: 6.9-6.14
46	Problems on Static Synchronous Series Compensator	CO 2	T3: 6.9-6.14
45	The unified and interline power flow controllers (UPFC and IPFC) The Principle, Control and Application	CO 4	T3: 6.9-6.14
46	STATCOM Control and Application	CO 4	T3: 6.9-6.14
DISCUSSION OF DEFINITION AND TERMINOLOGY			
47	Define FACTS	CO 1	T3: 6.9-6.14
48	Define SVC	CO 2	T2: 3.2-3.3
49	Define SSSC, TCSC	CO 3	T3:36.8
49	Define STATCOM,SSSC	CO 4	T2: 5.1-5.20
50	Define UPFC.IPFC	CO 4	T2: 6.1-5.22

51	FACTS devices linear and non linear controller interactions	CO 5	T2: 8.1-8.12
DISCUSSION OF QUESTION BANK			
52	Types of Controllers	CO 1	T2: 3.2-3.3
53	SVC design	CO 2	T3: 6.9-6.14
54	Design of TCSC,GCSC	CO 3	T2: 5.1-5.20
55	Use of UPSC,IPSC	CO 4	T2: 7.1-7.20
56	FACTS controller interactions	CO 5	T3:36.8

Course Coordinator **HOD,EEE**
Mr T Ravi Babu, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions	**10**

	5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**

PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project.	**12**

	6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	
PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**

PSO 3	Gain the hands-on competency skills in PLC automation, process controllers, HMI and other computing tools necessary for entry level position to meet the requirements of the employer. 1. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**