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

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**Modern Power System Analysis**				
Course Code	BPSC01				
Program	M.Tech				
Semester	I				
Course Type	Professional Core				
Regulation	PG-21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	-	-
Course Coordinator	Dr.Sayanti Chatterjee, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEC22	VI	Power System Analysis
B.Tech	AEEC34	VII	Power system Protection

II COURSE OVERVIEW:

Power system analysis deals formation impedance and admittance matrices for power system network, finding different electrical parameters for various buses in power system, study fault analysis and represent power system using per unit system, understand steady state and transient stability of power system.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Modern Power System Analysis	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Seminars	✓	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.

50%	To test the objectiveness of the concept
30%	To test the analytical skill of the concept
20%	To test the application skill of the concept

Continuous Internal Assessment (CIA):
For each theory course the CIA shall be conducted by the faculty / teacher handling the course. CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment / AAT shall be considered for computing the final CIA of a student in a given course.

The CIE Tests/Assignment /AAT shall be conducted by the course faculty with due approval from the HOD. Advance notification for the conduction of Assignment/AAT is mandatory and the responsibility lies with the concerned course faculty. CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Technical Seminar and Term Paper

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Assignment	AAT	
CIA Marks	20	5	5	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 9^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment:
To improve the writing skills in the course an assignment will be evaluated for 05 marks. One assignment has to submit at the end of the CIE2 for the questions provided by the each course coordinator in that semester. Assignments to be handed in as loose paper collection stapled together at the top left corner. The assignment should be presented as a professional report. It must consist of a cover sheet, content page, and should have an introduction, a body, a conclusion or recommendation, and a reference page.

Alternative Assessment Tool (AAT)
In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). This AAT enables faculty to design own assessment patterns during the CIA. The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. If properly applied, the AAT converts the classroom into an effective learning center.**The AAT may includes, concept videos, course related term paper, technical seminar, term paper, paper presentations conducted by reputed organizations relevant to the course etc.**

VI COURSE OBJECTIVES:

The students will try to learn:

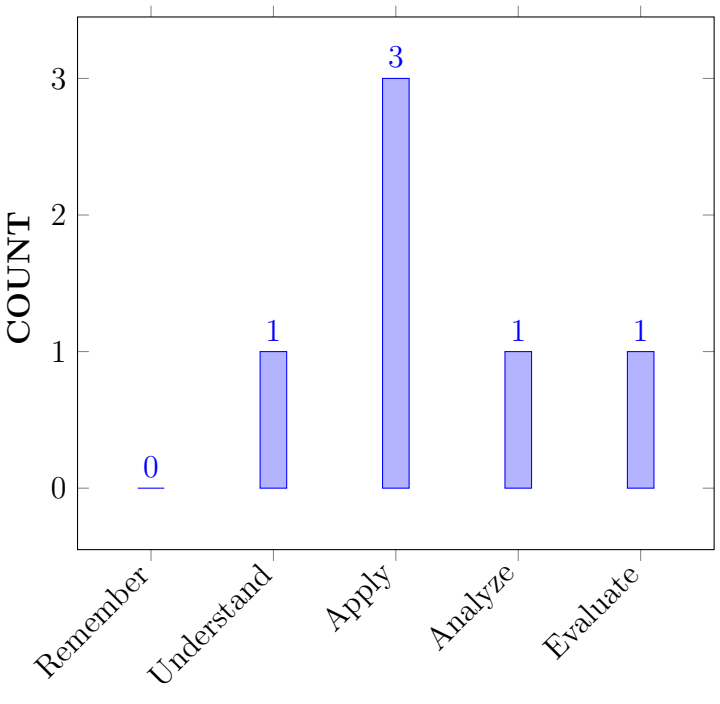
I	The need of numerical relays and their importance in digital protection of the power system.
II	The mathematical approach towards designing algorithms for the protection of power system.
III	The methods of protection employed for the transformers and transmission lines.

VII COURSE OUTCOMES:

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

CO 1	**Utilize** the representation of basic components and single line diagram of power system for understanding the restructuring of system	Apply
CO 2	**Examine** the optimal power flow solution using FACTS devices to solve power flow analysis problems using various methods.	Apply
CO 3	**Analyse** the new bus voltages contingency by adding/removal of lines for illustrating the various techniques for contingency evaluation and analysis.	Analyse
CO 4	**Evaluate** the operating states and security monitoring of power systems to describe its contingency analysis.	Evaluate
CO 5	**Understand** the importance of power flow analysis in planning and operation of power systems.	Understand
CO 6	**Apply** the various algorithms for state estimation to estimate different components and states of power systems.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	2	CIE/AAT/SEE
PO 2	An ability to write and present a substantial technical report / document.	3	CIE/AAT/SEE
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.	2	CIE/AAT/SEE
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	2	CIE/AAT/SEE
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.	1	CIE/AAT/SEE
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	1	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	✓	✓	✓	✓	-
CO 2	✓	✓	-	✓	✓	-
CO 3	✓	✓	✓	✓	-	✓
CO 4	✓	✓	✓	✓	✓	-
CO 5	✓	✓	✓	✓	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 6	✓	✓	✓	✓	✓	-

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 matched.
CO 1	PO 2	**Elucidate Term paper** on planning and power flow studies and semminer has been given .	3
	PO 3	**Make use of basics of basics power system analysis** .	7
	PO 4	Make use of basics of MATLAB for Y bus calculation .	4
	PO 5	**Demonstrate the graph theory** for Bus clculation .	2
CO 2	PO 1	textbfRecall the load flow analysis using GS-, NR for further research .	4
	PO 2	**Elucidate Term paper** on FACTS devices	4
	PO 3	**Apply Power flow analysis** to get mastery .	7
	PO 4	**Illustrate** the use of PSCAD and MATLAB for power flow analysis.	3
	PO 5	**Demonstrate the graph theory** for Bus clculation .	2
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.	1
	PO 2	Derive the expression for torque in wattmeter to solve complex engineering problems using basic mathematics and engineering principles.	4
	PO 3	**Derive the expression for sequence network** for fault calculation.	4
	PO 4	**Illustrate** the use of PSCAD and MATLAB for faultanalysis.	3
	PO 6	**Determine fault calculation** for further reserch.	2
CO 4	PO 1	Explain the concept of Unsymmetrical fault.	1
	PO 2	**Elucidate Term paper** on fault calculation	4
	PO 3	**Derive the expression for sequence network** for fault calculation.	4
	PO 4	**Illustrate** the use of PSCAD and MATLAB for faultanalysis.	3
	PO 5	**Demonstrate the computer programming** for fault clculation .	2
CO 5	PO 1	Identify the different Contigency methods the working of cathode ray oscilloscope applying basic knowledge of science and engineering fundamentals.	2
	PO 2	**Elucidate Term paper** on contigency analysis for multiple lines	4
	PO 3	**Derive the expression for sequence network** for contigency calculation.	6

	PO 4	**Illustrate** the use of PSCAD and MATLAB for matrix calculation.	4
CO 6	PO 1	Identify the state estimation applying basic knowledge of science and engineering fundamentals.	2
	PO 2	textbf Elucidate Term paper on different algorithm for state estimation	4
	PO 3	Illustrate the different protection and state estimation which helps to solve complex engineering problems	7
	PO 4	**Illustrate** the use of PSCAD and MATLAB for matrix calculation.	3
	PO 5	**Demonstrate the computer programming** for state eatimatiion .	3

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

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	3	7	4	2	-
CO 2	1	4	7	4	3	-
CO 3	1	4	6	3	-	2
CO 4	1	4	5	3	2	-
CO 5	2	3	6	4	-	-
CO 6	2	4	7	3	3	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	43	100	100	40	-
CO 2	25	57	100	100	50	-
CO 3	25	57	85	75	-	50
CO 4	25	57	72	75	40	-
CO 5	50	43	85	100	-	-
CO 6	50	57	100	75	50	-

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

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 3	1	2	3	3	2	2
CO 4	1	2	3	3	-	-
CO 5	2	2	3	3	2	-
CO 6	2	2	3	3	-	-
TOTAL	7	12	18	18	4	2
AVERAGE	1.4	2	3	3	2	2

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminar and term paper	-
Laboratory Practices	-	Student Viva	-	Mini Project	-

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	**End Semester OBE Feed Back**

XVII SYLLABUS:

MODULE I	**PLANNING AND OPERATIONAL STUDIES OF POWER SYSTEMS**
	Need for system planning and operational studies, basic components of a power system, introduction to restructuring, single line diagram, per phase and per UNIT analysis, generator, transformer, transmission line and load representation for different power system studies, primitive network, construction of Y-bus using inspection and singular transformation methods, Z-bus.
MODULE II	**POWER FLOW ANALYSIS**
	Importance of power flow analysis in planning and operation of power systems, statement of power flow problem, classification of buses, development of power flow model in complex variables form, iterative solution using Gauss-Seidel method, Q-limit check for voltage controlled buses, power flow model in polar form, iterative solution using Newton-Raphson method, decoupled and fast decoupled power flow solutions, DC power flow solution, power flow solution using FACTS devices, optimal power flow solution

MODULE III	**SHORTCIRCUITANALYSIS**
	Balanced faults: Importance of short circuit analysis, assumptions in fault analysis, analysis using Thevenins theorem, Z-bus building algorithm, fault analysis using Z-bus, computations of short circuit capacity, post fault voltage and currents. Unbalanced faults: Introduction to symmetrical components, sequence impedances, sequence circuits of synchronous machine, transformer and transmission lines, sequence networks analysis of single line to ground, line to line and double line to ground faults using Thevenins theorem and Z-bus matrix.
MODULE IV	**CONTINGENCY ANALYSIS**
	Contingency Evaluation: Operating states of a power system, concept of security monitoring, techniques for contingency evaluation, Importance of contingency analysis, addition / removal of one line, construction of a column of bus impedance matrix from the bus admittance matrix, calculation of new bus voltages due to addition / removal of one line, calculation of new bus voltages due to addition / removal of two lines .
MODULE V	**STATE ESTIMATION**
	Principles of transformer protection, digital protection of Transformer using FIR filter-based algorithm, least squares curve fitting based algorithms, Fourier-based algorithm, flux-restrained current differential relay; Digital Line differential protection: Current-based differential schemes, Composite voltage- and current- based scheme.

TEXTBOOKS

1. AG Phadke and J S Thorp, "Computer Relaying for Power Systems", Wiley/Research studies Press, 1st Edition, 2009.
2. AT Johns and S K Salman, "Digital Protection of Power Systems", IEEE Press, 1st Edition, 1999

REFERENCE BOOKS:

1. Gerhard Zeigler, "Numerical Distance Protection", Siemens Public Corporate Publishing, 1st Edition, 2006.
2. SRB hide "Digital Power System Protection" PHI Learning Pvt.Ltd. 3rd Edition, 2014

WEB REFERENCES:

1. . https://www.sciencedireect.com
2. https://www.spinger.com
3. https://www.ieeexplore.ieee.org/Xplore/home.jsp

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 Description on Outcome Based Education (OBE)		

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.	CO1	T4:9.2, R1:3.3-3.5
5	Forming Y bus formation by singular transformation. methods,	CO 1	T4:9.2, R1:3.3-3.5
6	Solve numerical problems on bus matrices.	CO 2	T4:9.2, R1:3.3-3.5
7	Formation of ZBUS: Partial network.	CO 3	T4:9.4, R1:4.1
8	Algorithm for the Modification of Z Bus Matrix for addition element from a new bus to reference.	CO 2	T4:9.3-9.5, R1:4.2
9	Algorithm for the Modification of Z Bus Matrix for addition element from a new bus to an old bus.	CO 3	T4: 9.3-9.5, R1:4.3-4.4
11	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 2	T4: 9.3-9.5, R1:4.3-4.4
12	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
13	Solution of load flow solutions using Gauss Seidel Method: Acceleration Factor.	CO 2	T4:9.8, R1:8.2
14	Load flow solution with and without P- V buses, Algorithm and Flowchart.	CO 2	T4:9.9.1, R1:9.2
15	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 1	T4:9.8, R1:9.2
16	Per Unit System	CO 1	T4:9.8, R1:9.2
17	Problems on Per Unit System	CO 1	T4:9.8, R1:9.2
18	Importance of Power flow.	CO 2	T4:10.6, R1:6.3
19	classification of buses	CO2	T4:10.6, R1:6.3

20	IDevelopment of power flow model	CO 2	T4:10.6, R1:6.3
21	Iterative solution using G-S method	CO2	T5:10.6, R1:7.3
22	Problems on Iterative solution using G-S method	CO2	T5:10.6, R1:7.3
23	Q-limit check using G-S method	CO2	T5:10.6, R1:7.3
24	Discuss on newton raphson method in rectangular form: load flow, solution with or without PV busses- Derivation of jacobian elements.	CO 4	T4:9.10, R1:9.2
25	Discussion newton raphson method in polar co- ordinates form: load flow solution with or without pv busses-Derivation of jacobian elements.	CO 4	T4:9.11.2, R1:9.2
26	Study on decoupled and fast decoupled methods for load flow solution.	CO 4	T4:9.12, R1:9.2
27	Problem discussion on decoupled and fast decoupled methods for load flow solution.	CO 4	T4:9.12, R1:9.2
28	Comparison of Different Methods – DC load Flow.	CO 4	T4:9.4.12, R1:9.2
29	Short Circuit Analysis: Short Circuit Current and MVA Calculations.	CO 3	T4:10.3, R1:6.1-6.3
30	Solving numerical problems (Symmetrical fault Analysis).	CO 6	T4:10.4, R1:6.4
31	Understand symmetrical component transformation, positive, negative and zero sequence components.	CO 4	T4:10.5, R1:6.4
32	Draw sequence networks.	CO 5	T4:10.6, R1:6.3
33	Derive sequence voltages, currents and impedances.	CO 6	T4:10.7, R1:6.3
34	Solving numerical problems on symmetrical components.	CO 4	T4:10.5, R1:6.3
35	Understand LG fault with and without fault impedance and numerical problems.	CO 4	T4:10.13, R1:6.3
36	Study fault with and without fault impedance and numerical problems.	CO 4	T4:10.13, R1:6.1-6.3
37	Determine LLG fault with and without fault impedance and numerical problems.	CO 4	T4:10.16, R1:6.1-6.3
38	Compare LG, LL, LLG faults with and without fault impedance and numerical problems.	CO 4	T4:10.17, R1:6.1-6.3
39	Contigency Evaluation.	CO 4	T4:10.17, R1:6.1-6.3
40	Introduction to steady state, dynamic and transient stabilities.	CO 3	T4:13.1, R1:10.1

41	Description of steady state stability power limit, transfer reactance, synchronizing power coefficient.	CO 3	T4:13.2, R1:10.3
42	Plot Power Angle Curve and determination of steady state,. stability.	CO 4	T4:13.2, R1:6.4
43	Explain methods to improve steady state stability.	CO 5	T4:13.2, R1:10.3
44	Derivation of swing equation.	CO 8	T4:13.3, R1:10.2
45	Determination of transient stability by equal area criterion.	CO 5	T4:13.6, R1:10.5
46	Application of equal area criterion to different cases.	CO 5	T4:13.7, R1:10.5
47	Discuss importance of FIR based method.	CO 5	T4:13.6, R1:10.5
48	Solving numerical problems on equal area criteria.	CO 5	T4:13.7, R1:10.5
49	Current based differential scheme.	CO 5	T4:13.7, R1:10.5
50	Composite voltage and Current based differential scheme.	CO 5	T4:13.7, R1:10.5
51	Discuss about Fourier-based algorithm	CO5	T1: 7.1
52	Discuss about flux-restrained current differential relay	CO5	T3: 5.7
43	Discuss about Digital Line differential protection	CO6	T2: 5.7
53	Discuss about Current-based differential schemes	CO6	T1: 9.1
54	Discuss about Composite voltage- and current- based scheme.	CO6	T1: 6.2
55	Mathematical Background To Digital Protection	CO1, CO2	T1: 2.1
56	Basic Elements Of Digital Protection of tranformer	CO3	T1: 3.2
57	FIR based Algorithms-I	CO4	T1: 4.2
58	Curve fitting algorithm	CO5	T1: 5.2
59	flux restrained current rely	CO6	T1: 6.2
60	flux restrained current rely	CO6	T1: 6.2
DISCUSSION OF QUESTION BANK			
61	Operational Studies of Power systems	CO1 CO2	-
62	Power flow analysis	CO1 CO2	-
63	Short Circuit Analysis	CO3, CO4	-
64	Contigency Analysis	CO5	-
65	State estimation	CO6	-

Signature of Course Coordinator **HOD,EEE**

INSTITUTE OF AERONAUTICAL ENGINEERING
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COURSE DESCRIPTION

Course Title	**ECONOMIC OPERATION OF POWER SYSTEMS**				
Course Code	BPSC02				
Program	M.Tech				
Semester	I	EPS			
Course Type	CORE				
Regulation	PG21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. A Naresh Kumar, Assistant Professor, EEE				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE004	III	DC Machines and Transformers
B.Tech	AEE007	IV	AC Machines
B.Tech	AEE008	VII	Power System Operation and Control

II COURSE OVERVIEW:

The course is intended to present fundamentals as well as state-of-the-art techniques for economic operation and control of electric power systems. The prerequisite for this course is a good background in power system fundamentals (e.g. undergraduate course on power system analysis). Details of the course assessment plans are given at the end. Much emphasis is given on the course project. The course project is different from the usual term papers. Unlike in the term papers, you are required to search for a suitable research topic related to the course content, and work on the problem throughout the semester. At the end of the semester, you are required to present a seminar on the chosen topic and submit a brief report. Guidance will be provided to you, if needed, in choosing and conducting the course project. The intention is to provide exposure to the methods of conducting a research work, and also to encourage independent and innovative ideas, which is also the main theme of this course..

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Industrial Load Modelling and Control	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	**x**	MOOC
x	Seminars	**x**	Others				

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VI COURSE OBJECTIVES:

The students will try to learn:

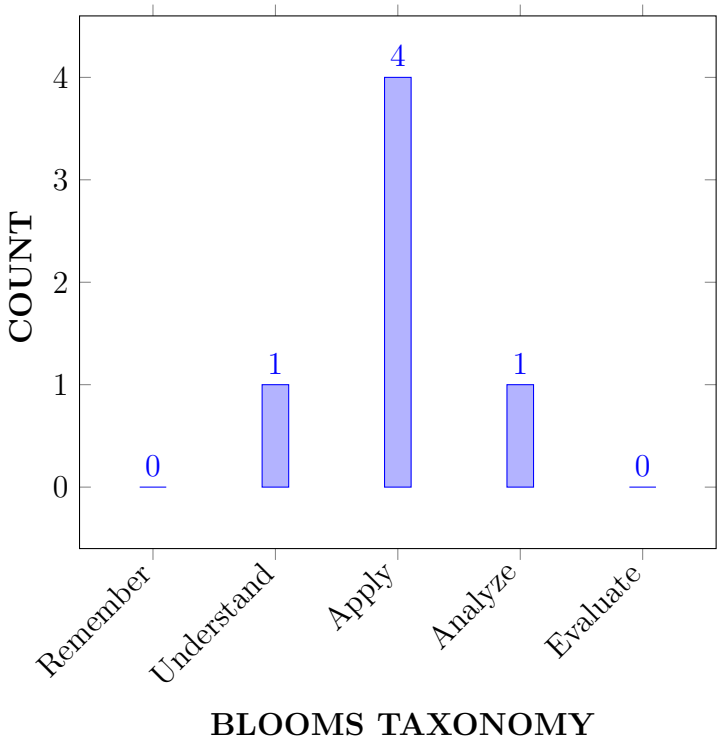
I	To understand the electrical power plant operation and control with respect to its economic aspect.
II	To know the importance of compensation in power system and study the different compensating techniques.
III	Study about different transients and their protection those are introduced in power system.

VII COURSE OUTCOMES:

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

CO 1	**Compute** the cost of generation, economic dispatch of power among thermal units using incremental cost curves and coordinate equation using iteration method	Apply
CO 2	**Solve** the unit Commitment problem with various constraints using conventional optimization techniques and general transmission line loss formula	Apply
CO 3	**Illustrate** the Optimal scheduling of Thermal and Hydro power stations for ideal economic operation of power systems	Understand
CO 4	**Categorize** single area load frequency control and two area load frequency control to minimize the transient deviations and steady state error to zero	Analyze
CO 5	**Analyse** the importance of Reactive power control and Power Factor in power systems for efficient and reliable operation of power systems.	Apply
CO 6	**Identify** the different types of compensating equipment for reducing reactive power to improve system's efficiency	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	2	CIE/AAT/SEE
PO 2	An ability to write and present a substantial technical report / document.	1	CIE/AAT/SEE
PO 3	Student should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.	2	CIE/AAT/SEE

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	2	CIE/AAT/SEE
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	2	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	✓	✓	-	-
CO 2	-	✓	✓	✓	-	-
CO 3	✓	✓	✓	✓	-	✓
CO 4	-	-	✓	✓	-	-
CO 5	-	-	-	✓	-	-
CO 6	-	-	✓	✓	-	-

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 matched.
CO 1	PO 3	Understand the concept of industrial load and analyze and design innovative models to establish innovative solution.	3
	PO 4	Make use of industrial load management techniques in power systems using the concepts of engineering fundamentals to develop the solution of problem formulation and abstraction to establish innovative solutions for Interpretation of results and Validation .	3
CO 2	PO 2	Illustrate the conceptual knowledge of electrical power systems for real time power system applications and with effective communication skills.	2
	PO 3	Illustrate the conceptual knowledge of electrical power systems for real time power system applications and with effective communication skills.	3
	PO 4	Understand the concept of industrial load on modern-day issues of Power Systems like industrial load management using advanced technologies with a global perspective.	4
CO 3	PO 1	Demonstrate research areas to solve practical problems in power systems and build solutions	2
	PO 2	Illustrate the conceptual knowledge of electrical power systems for real time power system applications and with effective communication skills.	2

	PO 3	Contrast the design process to minimize transmission line losses and energy saving in industries in electrical power systems for Solution development or experimentation / Implementation in Interpretation of results and Validation	4
	PO 4	Understand the concepts of heating loads and their effect on power system for real time energy management and the design process.	3
	PO 6	Implementation of real time energy management and the design process.	3
CO 4	PO 3	Demonstrate energy consumption of industrial loads by understanding and analyzing and design innovative solutions and Apply the complex engineering problems and their system components by design for the development of solution.	3
	PO 4	Make use of captive power plants in power systems using the concepts of engineering fundamentals to develop the solution of problem formulation and abstraction to establish innovative solutions for Interpretation of results and Validation	4
CO 5	PO 4	Understand the concepts of heating loads and their effect on power system for real time energy management.	4
CO 6	PO 3	Demonstrate operating strategies of power capacitors for integrated load management forapplication and solution of the complex engineering problems for the development of solution.	3
	PO4	Make use of power capacitors in power systems using the concepts of engineering fundamentals to develop the solution of problems and establish innovative solutions.	3

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

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

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	42.8	42.8	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 2	-	28.57	42.8	57.1	-	-
CO 3	50	28.57	57.1	42.8	-	50
CO 4	-	-	42.8	57.1	-	-
CO 5	-	-	-	57.1	-	-
CO 6	-	-	42.8	42.8	-	-

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					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	2	2	-	-
CO 2	-	1	2	2	-	-
CO 3	2	1	2	2	-	2
CO 4	-	-	2	2	-	-
CO 5	-	-	-	2	-	-
CO 6	-	-	2	2	-	-
TOTAL	2	2	10	12	-	2
AVERAGE	2	1	2	2	-	2

XV 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	-	-	-	-	

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	**End Semester OBE Feed Back**

XVII SYLLABUS:

MODULE I	**ECONOMIC LOAD SCHEDULING**
	Characteristics of steam turbine, variations in steam UNIT characteristics, economic dispatch with piecewise linear cost functions, Lambda iterative method, LP method, economic dispatch under composite generation production cost function, base point and participation factors, thermal system dispatching with network losses considered.
MODULE II	**UNIT COMMITMENT**
	UNIT Commitment, definition, constraints in UNIT commitment, UNIT commitment solution methods, priority, list methods, dynamic programming solution.
MODULE III	**HYDRO THERMAL SCHEDULING**
	Characteristics of Hydroelectric UNITs, introduction to hydrothermal coordination, long range and short range hydro scheduling. Hydroelectric plant models, hydrothermal scheduling with storage limitations, dynamic programming solution to hydrothermal scheduling.
MODULE IV	**LOAD FREQUENCY CONTROL**
	Control of generation, models of power system elements, single area and two area block diagrams, generation control with PID controllers, implementation of Automatic Generation control (AGC), AGC features.
MODULE V	**OPTIMAL POWER FLOW**
	Introduction to Optimal power flow problem, OPF calculations combining economic dispatch and power flow, OPF using DC power flow, algorithms for solution of the ACOPF, optimal reactive power dispatch.

TEXTBOOKS

1. J J Grainger W DStevenson, "Power system analysis", McGraw Hill,2nd Edition, 2003.
2. Allen J Wood, Bruce F Wollenberg, Gerald B Sheblé, "Power Generation, Operation and Control", WileyInterscience2nd Edition, 2013.

REFERENCE BOOKS:

1. Olle, Elgerd, "Electric Energy Systems Theory an Introduction", TMH, 2nd Edition, 1983.

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
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE)		
CONTENT DELIVERY (THEORY)			
1	Need for Electric Energy Scenario.	CO 1	T2:1.1,1.2
2	Need for Electric Energy Scenario.	CO 1	T2:1.1,1.2
3	Basic demand side management.	CO 1	T2:1.3,1.4
4	Basic demand side management.	CO 1	T2:1.3,1.4

5	Illustrate characteristics of steam turbine.	CO 1	T2: 1.1.1 –1.1.2
6	Illustrate characteristics of steam turbine.	CO 1	T2: 1.1.1 –1.1.2
7	Explain variations in steam unit characteristics.	CO 1	T2: 1.3.1
8	Explain variations in steam unit characteristics.	CO 1	T2: 1.3.1
9	Describe the operation of economic dispatch with piecewise linear cost functions.	CO 1	T2: 1.3.3
10	Describe the operation of economic dispatch with piecewise linear cost functions.	CO 1	T2: 1.3.3
11	Discuss the operation of Lambda iterative method.	CO 2	T1: 1.3.2 - 1.3.4
12	Discuss the operation of Lambda iterative method.	CO 2	T1: 1.3.2 - 1.3.4
13	Discuss the operation of s LP method.	CO 2	T2: 1.3.8
14	Discuss the operation of s LP method.	CO 2	T2: 1.3.8
15	Analyse the economic dispatch under composite generation production cost function.	CO 2	T1: 2.1 – 2.4
16	Analyse the economic dispatch under composite generation production cost function.	CO 2	T1: 2.1 – 2.4
17	Analyse base point and participation factors.	CO 2	T3: 5.2
18	Analyse base point and participation factors.	CO 2	T3: 5.2
19	Illustrate the thermal system dispatching with network losses considered.	CO 2	T1: 5.7
20	Illustrate the thermal system dispatching with network losses considered.	CO 2	T1: 5.7
21	Describe the UNIT Commitment.	CO 3	T3: 5.7
22	Describe the UNIT Commitment.	CO 3	T3: 5.7
23	Understand the definition and constraints in UNIT commitment.	CO 3	T2: 5.7
24	Understand the definition and constraints in UNIT commitment.	CO 3	T2: 5.7
25	Implement UNIT commitment solution methods.	CO 3	T3: 5.7
26	Implement UNIT commitment solution methods.	CO 3	T3: 5.7
27	Justify the priority list methods of unit commitment.	CO 3	T1: 9.1 -9.4
28	Justify the priority list methods of unit commitment.	CO 3	T1: 9.1 -9.4
29	Write about dynamic programming solution.	CO 3	T1: 9.1 -9.4
30	Write about dynamic programming solution.	CO 3	T1: 9.1 -9.4
31	Explain hydro thermal scheduling.	CO 4	T1: 9.1 -9.4
32	Explain Characteristics of Hydroelectric UNITs.	CO 4	T1: 9.1 -9.4

33	Write down the introduction to hydrothermal coordination.	CO 4	T1: 9.1 -9.4
34	Define long range and short range hydro scheduling.	CO 4	T1: 6.2 – 6.3
35	Describe Hydroelectric plant models.	CO 4	T1: 7.1 – 7.5
36	Describe hydrothermal scheduling with storage limitations.	CO 5	T1: 7.1 – 7.5
37	Develop Control of generation.	CO 5	T1: 7.1 – 7.5
38	Describe models of power system elements.	CO 5	T1: 7.2 -7.4
39	Describe single area and two area block diagrams.	CO 5	T1: 7.2 -7.4
40	Explain generation control with PID controller.	CO 5	T1: 7.2 -7.4
41	Describe implementation of Automatic Generation control (AGC).	CO 5	T1: 6.1 – 6.10
42	Know about AGC features.	CO 5	T1: 6.1 – 6.10
43	Explain the Optimal power flow problem.	CO 5	T1: 5.7
44	OPF calculations combining economic dispatch and power flow.	CO 6	T1: 2.2
45	Explain OPF using DC power flow.	CO 6	T1: 2.3
46	Describe the algorithms for solution of the ACOPF.	CO 6	T1: 5.7
47	Explain about optimal reactive power dispatch.	CO 6	T2: 2.1 - 2.4
48	Case studies, Captive power UNITs.	CO 5	R1:6.3
49	Operating and control strategies, Power pooling	CO 5	T2:13.7
50	Operating and control strategies, Power pooling	CO 4	T2:13.7
51	Power system operation models, Energy banking	CO 5	T1:13.6, R1:10.5
52	Power system operation models, Energy banking	CO 5	T1:13.6, R1:10.5
53	Develop Control of generation.	CO 5	T1: 7.1 – 7.5
54	Develop Control of generation.	CO 5	T1: 7.1 – 7.5
55	Develop Control of generation.	CO 5	T1: 7.1 – 7.5
41	Describe single area and two area block diagrams.	CO 5	T1: 7.2 -7.4
42	Describe single area and two area block diagrams.	CO 5	T1: 7.2 -7.4
43	Describe single area and two area block diagrams.	CO 5	T1: 7.2 -7.4

44	Describe implementation of Automatic Generation control (AGC).	CO 5	T1: 6.1 – 6.10
45	Describe implementation of Automatic Generation control (AGC).	CO 5	T1: 6.1 – 6.10
46	Describe implementation of Automatic Generation control (AGC).	CO 5	T1: 6.1 – 6.10
47	Explain the Optimal power flow problem.	CO 5	T1: 5.7
48	Explain the Optimal power flow problem.	CO 5	T1: 5.7
49	Explain the Optimal power flow problem.	CO 5	T1: 5.7
50	OPF calculations combining economic dispatch and power flow.	CO 6	T1: 2.2
51	OPF calculations combining economic dispatch and power flow.	CO 6	T1: 2.2
52	Describe the algorithms for solution of the ACOPF.	CO 6	T1: 5.7
53	Problems	CO 6	T1:486
54	Problems	CO 6	T1:486
55	Problems	CO5	R2:11.8
56	Describe the algorithms for solution of the ACOPF.	CO 6	T1: 5.7
57	Explain about optimal reactive power dispatch.	CO 6	T2: 2.1 - 2.4
58	Explain about optimal reactive power dispatch.	CO 6	T2: 2.1 - 2.4
59	Problems	CO6	T1:9.7, 9.8
60	Problems	CO6	T1:9.9
DISCUSSION OF QUESTION BANK			
1	MODULE:I-ECONOMIC LOAD SHEDDING	CO1	-
2	MODULE:II- UNIT COMMITMENT	CO2,CO3	-
3	MODULE:III-HYDRO THERMAL SCHEDULING	CO4	-
4	MODULE:IV-LOAD FREQUENCY CONTROL	CO5	-
5	MODULE:V-OPTIMAL POWER FLOW	CO6	-

Signature of Course Coordinator **HOD,EEE**
Dr.A Naresh Kumar,Assistant Professor

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

COURSE DESCRIPTION

Department	**ELECTRICAL POWER SYSTEMS**				
Course Title	**HYBRID ELECTRIC VEHICLES**				
Course Code	BPSC08				
Program	M.Tech				
Semester	I	EPS			
Course Type	Proffesional Elective				
Regulation	PG21				
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	AEEB11	III	Electrical Machines – I
UG	AEEB15	IV	Electrical Machines – II
UG	AEEB23	VI	Electric Drives and Static Control

II COURSE OVERVIEW:

Hybrid Electric 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 Hybrid Electric 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	✓	MOOC
x	Open Ended Experiments	x	Seminars	✓	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). **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 three sub divisions in a question.

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

50 %	To test the objectiveness of the concept
30 %	To test the analytical skill of the concept
20 %	To test the application skill of the concept

Continuous Internal Assessment (CIA):
For each theory course the CIA shall be conducted by the faculty / teacher handling the course. CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment / AAT shall be considered for computing the final CIA of a student in a given course.

The CIE Tests/Assignment /AAT shall be conducted by the course faculty with due approval from the HOD. Advance notification for the conduction of Assignment/AAT is mandatory and the responsibility lies with the concerned course faculty. CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Quiz/ Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Assignment	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 25 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/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:

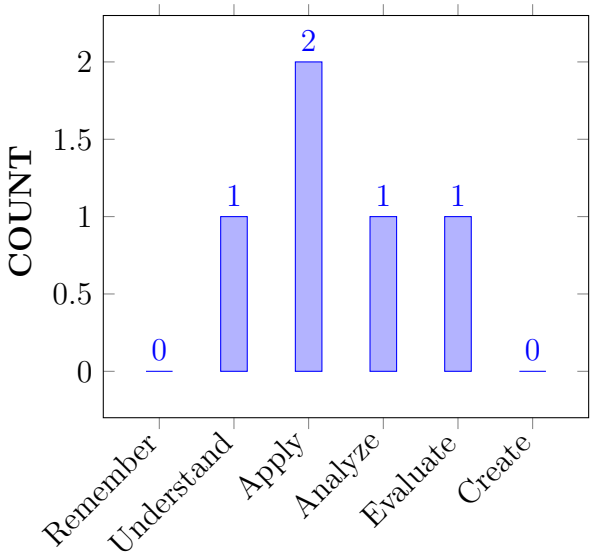
I	The concepts of modeling, design, and development of energy storage systems in hybrid electric vehicles.
II	The importance of hybrid electric vehicles to address the issues associated with environmental pollution and energy crisis.
III	The need of rapid control prototyping techniques to design and 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 basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals	Understand
CO 2	**Analyze** the use of different power electronics devices and electrical machines in hybrid electric vehicles.	Analyze
CO 3	**Demonstrate** the use of different energy storage devices used for hybrid electric vehicles, their technologies and control and select appropriate technology	Evaluate
CO 4	**Interpret** working of different configurations of electric vehicles and its components, hybrid vehicle configuration, performance analysis and Energy Management strategies in HEVs.	Apply
CO 5	**Develop** the electric propulsion unit and its control for hybrid electric vehicles.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



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VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**An ability** to independently carry out research/investigation and development work to solve practical problems.	3	CIE/SEE/AAT
PO 2	**An ability** to write and present a substantial technical report / document.	2	CIE/SEE/AAT
PO 3	**Student should be able to** demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.	2	CIE/SEE/AAT
PO 6	**Engage** in life-long learning for continuing education in doctoral level studies and professional development.	2	CIE/SEE/AAT

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PROGRAM OUTCOMES					
	1	2	3	4	5	6
CO 1	✓	-	-	-	-	-
CO 2	✓	✓	-	-	-	-
CO 3	✓	-	-	-	-	-
CO 4	✓	✓	✓	-	-	✓
CO 5	✓	-	-	-	-	-

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	**Apply** hybrid electric vehicles concepts in **Engineering knowledge, understanding and applications.**	3
	PO 2	Problem Analysis of hybrid electric vehicle concepts by identification, and system definition.	2
CO 2	PO 1	Apply the impact of modern drive-trains on Engineering knowledge, understanding and applications	3
	PO 2	Problem Analysis of modern drive-trains by identification, definition, formulation, information and validation for decarburization of energy supply.	2
CO 3	PO 1	Apply modeling techniques in hybrid electric vehicles for Engineering knowledge, understanding and applications.	3

	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	2
CO 4	PO 1	Develop electric drive-trains in hybrid electric vehicles for Engineering knowledge, understanding and applications.	3
	PO 2	Problem Analysis in identifying electric drive-trains by problem identification, system definition, formulation.	2
CO 5	PO 1	Develop electric drive-trains in hybrid electric vehicles for Engineering knowledge, understanding and applications.	3

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

COURSE OUTCOMES	Program Outcomes/ No. of Key Competencies Matched					
	1	2	3	4	5	6
CO 1	3	-	-	-	-	-
CO 2	3	2	-	-	-	-
CO 3	3	-	-	-	-	-
CO 4	3	2	2	-	-	2
CO 5	3	-	-	-	-	-

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

COURSE OUTCOMES	PROGRAM OUTCOMES					
	1	2	3	4	5	6
CO 1	100	0.0	0.0	0.0	0.0	0.0
CO 2	100	40	0.0	0.0	0.0	0.0
CO 3	100	0.0	0.0	0.0	0.0	0.0
CO 4	100	40	40	0.0	0.0	40
CO 5	100	0.0	0.0	0.0	0.0	0.0

XIII 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≤ C≤ 5% – No correlation
1-5 <C≤ 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES					
	1	2	3	4	5	6
CO 1	3	-	-	-	-	-
CO 2	3	2	-	-	-	-
CO 3	3	-	-	-	-	-
CO 4	3	2	2	-	-	2
CO 5	3	-	-	-	-	-
TOTAL	18	4	4	-	-	2
AVERAGE	3.0	2	2	-	-	2

XIV ASSESSMENT METHODOLOGY DIRECT:

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

XV ASSESSMENT METHODOLOGY INDIRECT:

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

XVI SYLLABUS:

MODULE I	**INTRODUCTION TO HYBRID AND ELECTRIC VEHICLES**
	History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies, basics of vehicle performance, vehicle power source characterization transmission characteristics, mathematical models to describe vehicle performance
MODULE II	**HYBRID TRACTION**
	Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive train topologies, fuel efficiency analysis.
MODULE III	**CONFIGURATION AND CONTROL OF DRIVES**
	Introduction to electric components used in hybrid and electric vehicles, configuration and control of dc motor drives, configuration and control of introduction motor drives. Configuration and control of permanent magnet motor drives configuration and control of switch reluctance, motor drives, drive system efficiency.
MODULE IV	**ELECTRIC MACHINE AND THE INTERNAL COMBUSTION ENGINE**
	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 AND STRATEGIES**
	Introduction to energy management and their strategies used in hybrid and electric vehicle, classification of different energy management strategies comparison of different energy management strategies Implementation issues of energy strategies.

TEXTBOOKS

1. Sira Ramirez, R Silva Ortigoza, "Control Design Techniques in Power Electronics Devices" Springer, 1 st Edition, 2004.
2. Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, "Sliding mode control of switching Power Converters", 1st Edition, 2002.

REFERENCE BOOKS:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design fundamentals, CRC Press, 1 st Edition 2003.
2. MehrdadEhsani, YimiGao, Sebastian E Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 1st Edition 2004
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 1st Edition 2003.
4. Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

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 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	CO1	T1: 1.1, 1.2
2	History of hybrid and electric vehicles	CO1	T1: 1.1, 1.2
3	Social and environmental import hybrid and electric vehicles.	CO1	T1: 1.1, 1.2
4	impact of modern drive-trains on energy supplies	CO2	T1: 1.2
5	Conventional Vehicles: Basics of performance, vehicle power source characterization	CO1	T1: 1.2
6	Transmission characteristics	CO1	T1: 1.3
7	Mathematical models to vehicle performance	CO1	T1: 3.6
8	Hybrid Electric Drive trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies	CO2	T1: 1.1
9	Power flow control in hybrid drive train topologies, fuel efficiency analysis	CO2	T1: 1.1, T1: 3.8

10	Electric Drive trains: Basic concept of electric traction, introduction to various electric drive train topologies	CO2	T1: 4.2,4.3
11	Power flow control in electric drive train topologies	CO3	T1: 4.2,4.3 T2:26.10
12	Fuel efficiency analysis	CO3	T1: 4.4
13	Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles	CO3	R2: 4.7
14	Configuration and control of DC motor drives	CO3	T1: 4.9
15	Configuration and control of Induction Motor drives	CO3	T1: 4.9
16	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
17	Drive system efficiency	CO3	T1: 5.1
18	Sizing the drive system: matching the electric machine and the internal combustion engine (ICE)	CO4	T1: 5.1
19	Sizing the propulsion motor, sizing the power electronics	CO4	T1: 5.1
20	Energy Storage: Introduction to energy storage requirements in hybrid vehicles	CO4	T1: 6.1,6.4,6.5
21	Energy Storage: Introduction to energy storage requirements in electric vehicles	CO4	T1: 6.1,6.4,6.5
22	Battery based energy storage and its analysis	CO4	T1: 6.1
23	Fuel cell based energy storage and its analysis	CO4	T1: 6.1
24	Super capacitor based energy storage and its analysis	CO4	T1: 6.1
25	Flywheel based energy storage and its analysis	CO4	T1: 6.1
26	Hybridization of different energy storage devices;,	CO4	T1: 6.13
27	Classification of different storage devices	CO4	R1: 6.14
28	Energy Storage: Introduction to energy storage requirements in hybrid vehicles	CO4	T1: 6.1,6.4,6.5
29	Energy Storage: Introduction to energy storage requirements in electric vehicles	CO4	T1: 6.1,6.4,6.5
30	Battery based energy storage and its analysis	CO4	T1: 6.1
31	Fuel cell based energy storage and its analysis	CO4	T1: 6.1
32	Super capacitor based energy storage and its analysis	CO4	T1: 6.1
33	Flywheel based energy storage and its analysis	CO4	T1: 6.1
34	Hybridization of different energy storage devices;,	CO4	T1: 6.13
35	Classification of different storage devices	CO4	R1: 6.14
36	Selecting the energy storage technology	CO4	T1 : 9
37	Communications	CO5	T1: 9.5
38	supporting subsystems	CO5	T1: 9.5
39	Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles	CO5	R2: 9.6 R3: 1.5, 1.9
40	Classification of different energy management strategies	CO5	T1: 9.1 R3: 2.6

41	Comparison of different energy management strategies	CO5	T1: 9.1 R3: 4.3, 4.8
42	Management strategies	CO5	R1: 9.9 R3:5.8, 5.11
43	Introduction to energy management strategies used in hybrid vehicles	CO5	T1 : 9.1
44	Introduction to energy management strategies used in electric vehicles	CO5	T1 : 9.1
45	Classification of different energy management strategies	CO5	T1 : 9.1
46	Implementation issues of energy management strategies	CO5	T1 : 9.1
47	comparison of different energy management strategies	CO5	T1 : 9.1
48	Case Studies: design of a hybrid electric vehicle (HEV)	CO5	T1 : 9.1
49	Design of a battery electric vehicle (BEV).	CO5	T1 : 9.1
50	Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles	CO5	R2: 9.6 R3: 1.5, 1.9
51	Classification of different energy management strategies	CO5	T1: 9.1 R3: 2.6
52	Comparison of different energy management strategies	CO5	T1: 9.1 R3: 4.3, 4.8
53	Management strategies	CO5	R1: 9.9 R3:5.8, 5.11
54	Introduction to energy management strategies used in hybrid vehicles	CO5	T1 : 9.1
55	Introduction to energy management strategies used in electric vehicles	CO5	T1 : 9.1
56	Classification of different energy management strategies	CO5	T1 : 9.1
57	Implementation issues of energy management strategies	CO5	T1 : 9.1
58	comparison of different energy management strategies	CO5	T1 : 9.1
59	Case Studies: design of a hybrid electric vehicle (HEV)	CO5	T1 : 9.1
60	Design of a battery electric vehicle (BEV).	CO5	T1 : 9.1
DISCUSSION OF QUESTION BANK			
1	Mathematical models to vehicle performance	CO1	R4:2.1
2	Hybrid Electric Drive trains	CO2	T4:7.3
3	Induction motor	CO3	R4:5.1
4	Electric Battery	CO4	T1:7.5
5	Energy management	CO5	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	**HVDC Transmission and FACTS**				
Course Code	BPSC03				
Program	M.Tech				
Semester	I				
Course Type	Program Core Elective				
Regulation	PG21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	-	-
Course Coordinator	Dr. P Sridhar, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB20	V	Power Electronics
B.Tech	AEEB22	VI	Power system Analysis
B.Tech	AEEB47	VII	High Voltage Engineering

II COURSE OVERVIEW:

This course deals with the importance of FACTS controllers and HVDC transmission, analysis of HVDC converters, Harmonics and Filters, Reactive power control and Power factor improvements of the system. It also deals with basic modeling nd analysis of HVDC system power flow regulation.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
HVDC Transmission and FACTS	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.

50%	To test the objectiveness of the concept
30%	To test the analytical skill of the concept
20%	To test the application skill of the concept

Continuous Internal Assessment (CIA):
For each theory course the CIA shall be conducted by the faculty / teacher handling the course. CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment / AAT shall be considered for computing the final CIA of a student in a given course.

The CIE Tests/Assignment /AAT shall be conducted by the course faculty with due approval from the HOD. Advance notification for the conduction of Assignment/AAT is mandatory and the responsibility lies with the concerned course faculty. CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Technical Seminar and Term Paper

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Assignment	AAT	
CIA Marks	20	5	5	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 9^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment:
To improve the writing skills in the course an assignment will be evaluated for 05 marks. One assignment has to submit at the end of the CIE2 for the questions provided by the each course coordinator in that semester. Assignments to be handed in as loose paper collection stapled together at the top left corner. The assignment should be presented as a professional report. It must consist of a cover sheet, content page, and should have an introduction, a body, a conclusion or recommendation, and a reference page.

Alternative Assessment Tool (AAT)
In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). This AAT enables faculty to design own assessment patterns during the CIA. The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. If properly applied, the AAT converts the classroom into an effective learning center.**The AAT may includes, concept videos, course related term paper, technical seminar, term paper, paper presentations conducted by reputed organizations relevant to the course etc.**

VI COURSE OBJECTIVES:

The students will try to learn:

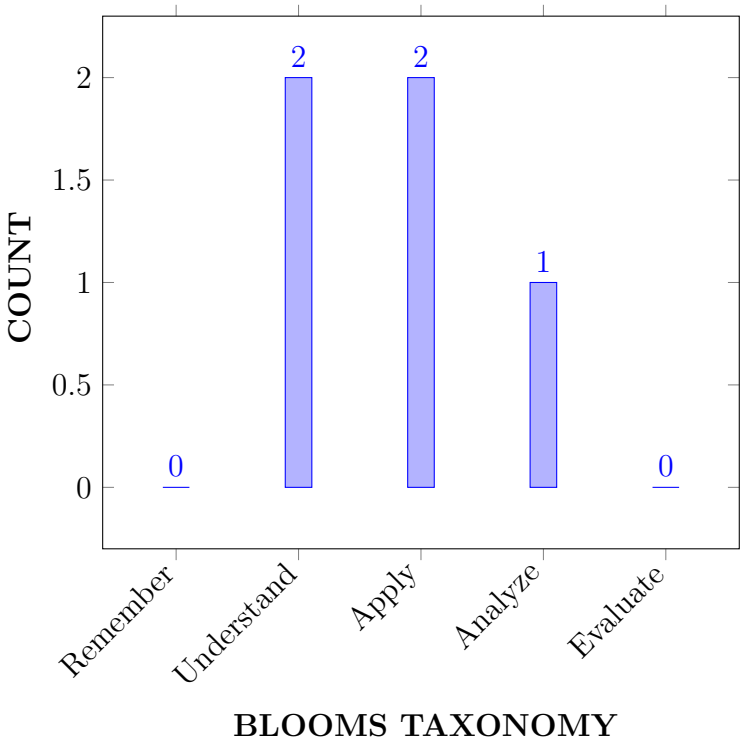
I	The fundamentals of FACTS Controllers.
II	The importance of controllable parameters and types of FACTS controllers and their benefits.
III	The basic concepts of HVDC system, components used in HVDC system and advantages of DC over AC transmission systems.
IV	The functioning of components of HVDC system and various controlling techniques for stability enhancement in HVDC links.

VII COURSE OUTCOMES:

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

CO 1	**Explain** the basic fundamentals of FACTS controllers.	Understand
CO 2	**Interpret** the enhancement of stability using static shunt and series compensation.	Understand
CO 3	**Model and Design** of coordinating multiple FACTS controllers UPFC and IPFC using control techniques.	Apply
CO 4	**Develop** the knowledge of HVDC transmission and HVDC converters and the applicability and advantage of HVDC transmission over conventional AC transmission.	Apply
CO 5	**Simplify and Solve** mathematical problems related to rectifier and inverter control methods and learn about different control schemes as well as starting and stopping of DC links.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	1	SEE/CIE/AAT
PO 2	An ability to write and present a substantial technical report / document.	2	SEE/CIE/AAT
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.	3	SEE/CIE/AAT
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	2	SEE/CIE/AAT
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	2	SEE/CIE/AAT

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
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 matched.
CO 1	PO 1	Demonstrate the importance of FACTS controllers and understand control characteristics of FACTS system for solving society relevant problems for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions to get the solution development.	2
	PO 2	Apply the concepts (knowledge) of FACTS systems using their control characteristics by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations and communicate effectively in writing / orally societal problems.	4
	PO 3	Demonstrate the importance of FACTS transmission and understand control characteristics of FACTS system for solving society relevant problems for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions to get the solution development.	5
	PO 6	Demonstrate the importance of FACTS transmission and understand control characteristics of FACTS system in life-long learning for continuing education in doctoral level studies and professional development.	2
CO 2	PO 1	Demonstrate the working of series and shunt compensation for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions and manage the design process.	1
	PO 2	Apply the concepts (knowledge) of series and shunt compensation in stability enhancement by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations and communicate effectively in writing / orally societal problems. science and engineering fundamentals.	4
	PO 3	Demonstrate the working of series and shunt compensation in stability enhancement for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions and manage the design process and evaluate outcomes using modern tools to get the solution development and communicate effectively in writing / orally societal problems. science and engineering fundamentals.	5

	PO 4	Demonstrate the working of series and shunt compensation in stability enhancement for applying knowledge, understanding and demonstrations of power system applications in real time complex problems and use creativity to establish innovative solutions and manage the design process and evaluate outcomes using modern tools to get the solution development and communicate effectively in writing / orally societal problems. science and engineering fundamentals.	3
	PO 6	Demonstrate the working of series and shunt compensation in stability enhancement in life-long learning for continuing education in doctoral level studies and professional development.	3
CO 3	PO 1	Demonstrate the importance of multiple FACTS controllers UPFC and IPFC for solving society relevant problems for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions.	1
	PO 2	Apply the concepts (knowledge) of multiple FACTS controllers UPFC and IPFC by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations and communicate effectively in writing / orally societal problems. science and engineering fundamentals.	4
	PO 3	Demonstrate the importance of multiple FACTS controllers UPFC and IPFC for solving society relevant problems for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions and manage the design process and evaluate outcomes using modern tools to get the solution development.	5
	PO 4	Apply the concepts (knowledge) of multiple FACTS controllers UPFC and IPFC by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations and use creativity to establish the solutions and make the experimental design.	3
	PO 6	Apply the concepts (knowledge) of multiple FACTS controllers UPFC and IPFC in life-long learning for continuing education in doctoral level studies and professional development.	2
CO 4	PO 1	Demonstrate the importance of AC and DC transmission and understand control characteristics of HVDC system for solving society relevant problems for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions to get the solution development.	1

	PO 2	Apply the concepts (knowledge) of HVDC systems using their control characteristics by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations and communicate effectively in writing / orally societal problems.	4
	PO 3	Demonstrate the importance of AC and DC transmission and understand control characteristics of HVDC system for solving society relevant problems for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions to get the solution development.	5
	PO 4	Demonstrate the importance of AC and DC transmission and understand control characteristics of HVDC system for solving society relevant complex problems for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions to get the solution development.	2
	PO 6	Demonstrate the importance of AC and DC transmission and understand control characteristics of HVDC system in life-long learning for continuing education in doctoral level studies and professional development.	3
CO 5	PO 1	Demonstrate the working of HVDC converter and design new innovative products for solving society relevant problems for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions and manage the design process and evaluate outcomes using modern tools to get the solution development.	1
	PO 2	Apply the concepts (knowledge) of HVDC converter using their rectifier and inverter operations by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations and use creativity to establish the solutions and make the experimental design and communicate effectively in writing / orally societal problems. science and engineering fundamentals.	4
	PO 3	Demonstrate the working of HVDC converter and design new innovative products for solving society relevant problems for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions and manage the design process and evaluate outcomes using modern tools to get the solution development.	5

	PO 4	Demonstrate the working of HVDC converter and design new innovative products for solving society relevant problems for applying knowledge, understanding and demonstrations of power system applications in real time complex problems and use creativity to establish innovative solutions and manage the design process and evaluate outcomes using modern tools to get the solution development.	3
	PO 6	Demonstrate the working of HVDC converter and design new innovative products in life-long learning for continuing education in doctoral level studies and professional development.	2

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

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

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	50.0	57.14	71.43	-	-	40.0
CO 2	25.0	57.14	71.43	75.0	-	60.0
CO 3	25.0	57.14	71.43	75.0	-	40.0
CO 4	25.0	57.14	71.43	50.0	-	60.0
CO 5	25.0	57.14	71.43	75.0	-	40.0

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

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 4	1	2	3	2	-	3
CO 5	1	2	3	3	-	1
TOTAL	5	10	15	11	-	9
AVERAGE	1.0	2.0	3.0	2.2	-	1.8

XV 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	-	-	-	-	

XVI ASSESSMENT METHODOLOGY-INDIRECT:

✓	**End Semester OBE Feed Back**

XVII SYLLABUS:

MODULE I	**FACTS CONCEPTS**
	Reactive power control in electrical power transmission, principles of conventional reactive power compensators. Introduction to FACTS, flow of power in AC parallel paths, meshed systems, basic types of FACTS controllers, definitions of FACTS controllers, brief description of FACTS controllers.
MODULE II	**STATIC SHUNT AND SERIES COMPENSATORS**
	Shunt compensation – objectives of shunt compensation, methods of controllable VAR generation, static VAR compensators – SVC, STATCOM, SVC and STATCOM comparison. Series compensation – objectives of series compensation, thyristor switched series capacitors (TCSC), static series synchronous compensator (SSSC), power angle characteristics, and basic operating control schemes.
MODULE III	**COMBINED COMPENSATORS**
	Unified power flow controller (UPFC) – Introduction, operating principle, independent real and reactive power flow controller and control structure. Interline power flow controller (IPFC), Introduction to Active power filtering, Concepts relating to Reactive power compensation and harmonic current compensation using Active power filters.

MODULE IV	**HVDC TRANSMISSION**
	HVDC Transmission system: Introduction, comparison of AC and DC systems, applications of DC transmission, types of DC links, Layout of HVDC Converter station and various equipments. HVDC Converters, analysis of bridge converters with and without overlap, inverter operation, equivalent circuit representation of rectifier and inverter configurations.
MODULE V	**CONTROL OF HVDC SYSTEM**
	Principles of control, desired features of control, converter control characteristics, power reversal, Ignition angle control, current and extinction angle control. Harmonics introduction, generation, ac filters and dc filters. Introduction to multiterminal DC systems and applications, comparison of series and parallel MTDC systems, Voltage Source Converter based HVDC system.

TEXTBOOKS

1. J Arrillaga, "High Voltage Direct Transmission", Peter Peregrinus Ltd. London, 1st Edition, 1983.
2. K R Padiyar, "HVDC Power Transmission Systems", Wiley Eastern Ltd., 1st Edition, 1990.

REFERENCE BOOKS:

1. E. W. Kimbark, "Direct Current Transmission", Vol. I, Wiley Interscience, 1st Edition, 1971.
2. Erich Uhlmann, "Power Transmission by Direct Current", B.S. Publications, 1st Edition, 2004.
3. SN Singh, "Electric Power Generation, Transmission and Distribution, PHI, New Delhi, 2nd Edition, 2008.
4. 4. V Kamaraju, "HVDC Transmission" Tata McGraw-Hill Education Pvt Ltd, New Delhi, 2nd Edition, 2011.

WEB REFERENCES:

1. . https://www.sciencedireect.com
2. https://www.spinger.com
3. https://www.ieeexplore.ieee.org/Xplore/home.jsp

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 Description on Outcome Based Education(OBE)		
CONTENT DELIVERY (THEORY)			
1	Introduction of DC power transmission technology	CO 1	T4:9.41, R1:3.1-3.2

2	Understand Economics of HVDC transmission	CO 1	T4:9.4.1, R1:3.1-3.2
3	Comparison of AC and DC Transmission	CO 1	T4:9.4.3, R1:3.3-3.5
4	Terminal equipment of HVDC	CO1	T4:9.2, R1:3.3-3.5
5	Application of DC transmission system	CO 1	T4:9.2, R1:3.3-3.5
6	Reliability of HVDC systems, limitation of HVDC transmission	CO 2	T4:9.2, R1:3.3-3.5
7	Modern trends in DC transmission	CO 3	T4:9.4, R1:4.1
8	Single phase and three phase converters	CO 2	T4:9.3-9.5, R1:4.2
9	Properties and characteristics of HVDC converter	CO 3	T4: 9.3-9.5, R1:4.3-4.4
10	Choice of converter configuration	CO 3	T4: 9.3-9.5, R1:4.3-4.4
11	Planning for HVDC transmission, modern trends in DC transmission.	CO 2	T4: 9.3-9.5, R1:4.3-4.4
12	Simplified analysis of Graetz circuit	CO 2	T4:9.1, R1:8.1
13	Features of rectification circuit for HVDC transmission	CO 2	T4:9.8, R1:8.2
14	Different modes of operation of converter	CO 2	T4:9.9.1, R1:9.2
15	Characteristics of a twelve-pulse converter	CO 4	T4:9.8, R1:9.2
16	Output voltage waveforms in rectification process	CO 4	T4:9.10, R1:9.2
17	Output voltage waveforms in inverter operation	CO 4	T4:9.10, R1:9.2
18	Introduction to grid control	CO 4	T4:9.11.2, R1:9.2
19	Limitations in manual control and development of control schemes	CO 4	T4:9.12, R1:9.2

20	Constant current vs constant voltage	CO 4	T4:9.4.12, R1:9.2
21	Desired features of converter	CO 3	T4:10.3, R1:6.1-6.3
22	Control schemes of HVDC converter	CO 5	T4:10.4, R1:6.4
23	Principle of DC Link Control	CO 4	T4:10.5, R1:6.4
24	Converter control characteristics	CO 5	T4:10.6, R1:6.3
25	Firing angle control	CO 5	T4:10.7, R1:6.3
26	Current and extinction angle control	CO 5	T4:10.7, R1:6.3
27	Effect of source inductance on the system	CO 4	T4:10.5, R1:6.3
28	Stability of control and tap changer control	CO 4	T4:10.13, R1:6.3
29	Power control, current limits and Frequency control	CO 4	T4:10.16, R1:6.1-6.3
30	Converter mal operations	CO 4	T4:10.17, R1:6.1-6.3
31	Reasons for commutation failure and its effects on equipment	CO 3	T4:13.1, R1:10.1
32	Starting and shutting down of converter bridge	CO 3	T4:13.2, R1:10.3
33	Protection against over current and over voltage in converter station	CO 4	T4:13.2, R1:6.4
34	Sources of reactive power	CO 5	T4:13.2, R1:10.3
35	AC Filters	CO 4	T4:13.3, R1:10.2
36	Modeling of DC Links	CO 5	T4:13.6, R1:10.5
37	DC Network-DC Converter-Controller Equations	CO 5	T4:13.7, R1:10.5
38	solution of DC load flow	CO 5	T4:13.6, R1:10.5
39	Solution of AC-DC power flow	CO 5	T4:13.7, R1:10.5
40	Simultaneous method.	CO 5	T4:13.7, R1:10.5
41	Discuss about Sequential method	CO5	T1: 7.1
42	Discuss about Converter faults	CO5	T3: 5.7
43	Discuss about Generation of harmonics.	CO4	T2: 5.7

44	Discuss about Characteristics harmonics, calculation of AC harmonics	CO4	T1: 9.1
45	Discuss about Non characteristics of Harmonics, adverse effects of harmonics.	CO4	T1: 6.2
46	General Aspects Of HVDC Transmission	CO1, CO2	T1: 2.1
47	Analysis of Bridge Converter	CO3	T1: 3.2
48	HVDC Control Techniques	CO4	T1: 4.2
49	Converter Faults And Protection	CO5	T1: 5.2
50	Reactive Power Management	CO5	T1: 6.2
51	Discuss about Sequential method	CO5	T1: 7.1
52	Discuss about Converter faults	CO5	T3: 5.7
53	Discuss about Generation of harmonics.	CO4	T2: 5.7
54	Discuss about Characteristics harmonics, calculation of AC harmonics	CO4	T1: 9.1
55	Discuss about Non characteristics of Harmonics, adverse effects of harmonics.	CO4	T1: 6.2
56	General Aspects Of HVDC Transmission	CO1, CO2	T1: 2.1
57	Analysis of Bridge Converter	CO3	T1: 3.2
58	HVDC Control Techniques	CO4	T1: 4.2
59	Converter Faults And Protection	CO5	T1: 5.2
60	Reactive Power Management	CO5	T1: 6.2
DISCUSSION OF QUESTION BANK			
51	Mathematical Background To Digital Protection	CO1 CO2	-
61	General Aspects Of HVDC Transmission	CO1 CO2	-
62	Analysis of Bridge Converter	CO3	-
63	HVDC Control Techniques	CO4	-
64	Converter Faults And Protection	CO5	-
65	Reactive Power Management	CO5	-

Signature of Course Coordinator **HOD,EEE**

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

ELECTRICAL AND ELECTRONICS ENGINEERING
COURSE DESCRIPTION

Course Title	**INTERNET OF THINGS LABORATORY**				
Course Code	BPSC12				
Program	M.Tech				
Semester	I	EEE			
Course Type	Core				
Regulation	IARE - PG21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	4	2
Course Coordinator	Dr. P Sridhar, Professor				

I COURSE OVERVIEW:

The main objective of the course is to provide knowledge on internet of things and how important it is in present scenario. IoT is a connecting bridge between physical world and cyber world and Machine to Machine communication i.e. with automation as one subset. IoT refers to uniquely identifiable objects and their virtual representations in an Internet like structure. Measurement of various electrical quantities and functioning of induction motor in the case of over voltage, current is using arduino. Design a relay to protect the home appliances from over currents, under voltages and over voltages.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECC05	VI	Microcontrollers and Digital Signal Processing Laboratory

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Internet of Things 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. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	Understand the IoT using Arduino programming
II	Explain the interfacing of data, I/O devices with Arduino UNO
III	Describe the digital protection schemes in power system relays.

VII COURSE OUTCOMES:

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

CO 1	**List** the different IOT applications and importance of IOT in present scenario .	Remember
CO 2	**List** the application of Arduino forNode MCU	Remember
CO 3	**Know** the different sensors available to measure the current and voltage	Remember
CO 4	**Design** the digital voltmeter and ammeter for both AC and DC circuits	Analyse
CO 5	**Design** a digital frequency meter to measure the frequency in an AC circuit.	Analyse
CO 6	**Measure** the power and energy consumption in a home using Arduino	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL

VIII PROGRAM OUTCOMES:

	Program Outcomes
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.

Program Outcomes	
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	3	Lab Exercises
PO 2	An ability to write and present a substantial technical report / document.	3	Lab Exercises
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.	3	Lab Exercises
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	3	Lab Exercises
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.	2	Lab Exercises
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Observe theconcept of Internet of Things solving **practical problems**	2
	PO 2	Illustrate the concept of Internet of Things **a substantial technical report**	4
CO 2	PO 1	Observe the Arduino programming solving **practical problems**	3
	PO 3	Illustrate the Arduino programming**analyzing real-life engineering problems**	2

CO 3	PO 1	Observe the characteristics of bluetooth modules solving **practical problems**	2
	PO 3	Illustrate the characteristics of bluetooth modules**analyzing real-life engineering problems**	4
CO 4	PO 1	Observe the features of various algorithms applicable solving **practical problems**	3
	PO 3	Illustrate the features of various algorithms applicable solving **analyzing real-life engineering problems**	1
CO 5	PO 1	Observe the digital relying algorithms solving **practical problems**	3
	PO 2	Illustrate the digital relying algorithms **a substantial technical report**	4
CO 6	PO 1	Observe the features of various algorithms applicable solving **practical problems**	3
	PO 3	Illustrate the features of various algorithms applicable **analyzing real-life engineering problems**	1

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

COURSE OUTCOMES	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	4	-	-	-	-
CO 2	3	-	2	-	-	-
CO 3	2	-	4	-	-	-
CO 4	3	-	1	-	-	-
CO 5	3	4	-	-	-	-
CO 6	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	**ARDUINO BASED DIGITAL VOLTMETER, AMMETER**
	Design of digital voltmeter and ammeter using Arduino
WEEK II	**ARDUINO BASED WATTMETER, ENERGY METER**
	Design of digital wattmeter and energy meter using Arduino.
WEEK III	**CONROLLING RGB LED**
	Programming for Controlling RGB LED using Arduino and Wi-Fi module
WEEK IV	**IOT TO CONTROL REMOTE LED**
	Programming for Internet of things with Android and Arduino. Build an Arduino based IoT to control a remote LED.
WEEK V	**INTERFACING BLUETOOTH MODULE**
	Programming for how to interface HC-05 Bluetooth module with Arduino UNO for control of small dc motor.
WEEK VI	**INTERFACING TO TEMPERATURE SENSOR**
	Programming to Interface temperature sensor and monitoring the room temperature using IoT with Arduino Uno and display the digital value on LCD screen
WEEK VII	**INTERFCAING IR SENSOR**
	Programming to Interface IR sensors and Bluetooth for detecting obstacle using Arduino with android Application.
WEEK VIII	**INTERFACE TO MOTION AND GAS SENSOR**
	Programming to interface a motion sensor to use GPIO pins with a Raspberry Pi Programming to interface Gas sensor for detection and monitoring of harmful gases using Arduino and IoT.
WEEK IX	**SEND DATA FROM ARDUINO TO WEB PAGE**
	Programming for how to send data from Arduino to Webpage using Wi-Fi module.
WEEK X	**DIGITAL PROTECTION OF THREE PHASE INDUCTION MOTOR**
	Studying the ON / OFF control strategies of small dc motor using IoT.
WEEK XI	**DIGITAL PROTECTION OF TRANSFORMERS AND TRANSMISSION LINES**
	Study the protection schemes of three phase induction motor against over current and under voltage at remote location through IoT.
WEEK XII	**OVER CURRENT RELAY**
	Design of over current relay in distribution system and displaying the tripping status of the relay through IoT

TEXTBOOKS

1. Samuel Greengard, K B Kanchandhani, "The Internet of Things", Tata Mc Graw Hill Publishing Company, 2nd Edition, 1998.
2. Cuno Pfister, "Getting started with Internet of Things", Khanna Publishers, 5th Edition, 2012.

REFERENCE BOOKS:

1. Vedam Subramanyam, "Learning Internet of Things", New Age International Limited, 2nd Edition, 2006.

2. Klaus Schwab, "The Fourth Industrial Revolution", New Age International Limited, 2nd Edition, 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	Design of digital voltmeter and ammeter using Arduino	CO 1	T1:3.1
2	Design of digital wattmeter and energy meter using Arduino.	CO 2	T1:3.11
3	Programming for Controlling RGB LED using Arduino and Wi-Fi module	CO 3	T1:4.8
4	Programming for Internet of things with Android and Arduino. Build an Arduino based IoT to control a remote LED.	CO 2	T1:4.8
5	Programming for how to interface HC-05 Bluetooth module with Arduino UNO for control of small dc motor.	CO 3	T1.5.5
6	Programming to Interface temperature sensor and monitoring the room temperature using IoT with Arduino Uno and display the digital value on LCD screen	CO 4	T1:5.6
7	Programming to Interface IR sensors and Bluetooth for detecting obstacle using Arduino with android Application.	CO 4	T1:8.3
8	Programming to interface a motion sensor to use GPIO pins with a Raspberry Pi Programming to interface Gas sensor for detection and monitoring of harmful gases using Arduino and IoT.	CO 5	T1:8.3
9	Programming for how to send data from Arduino to Webpage using Wi-Fi module.	CO 3	T1:9.2
10	Studying the ON / OFF control strategies of small dc motor using IoTl	CO 5	T1:9.3
11	Study the protection schemes of three phase induction motor against over current and under voltage at remote location through IoT.	CO 3	T1:10.6
12	Design of over current relay in distribution system and displaying the tripping status of the relay through IoT	CO 6	T1:10.7

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Determine theinterface a motion sensor to use GPIO pins with a Raspberry Pi
2	Determine the Controlling RGB LED
3	Determine the interface a motion sensor
4	Determine the protection schemes of three phase induction motor against over current and under voltage at remote location
5	Determine the ON / OFF control strategies of small dc motor

Signature of Course Coordinator **HOD, EEE**
Dr. P Sridhar, Professor

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

ELECTRICAL AND ELECTRONICS ENGINEERING
COURSE DESCRIPTION

Course Title	**POWER SYSTEM COMPUTATIONALLABORATORY**				
Course Code	BPSC11				
Program	M.Tech				
Semester	I	EEE			
Course Type	Core				
Regulation	IARE - PG 21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	4	2
Course Coordinator	Mr. P. Shivakumar, Assistant Professor				

I COURSE OVERVIEW:

The objective of power system computational laboratory is to analyze electrical power system in steady state and transient state. In steady state the power system parameters are obtained by different load flow methods. In transient state the system stability is analyzed. Also, the formation of Ybus and Zbus is explained. In addition to this, the other methods of power system analysis mentioned here are unit commitment and state estimation. The simulation tool adopted is MATLAB.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECC05	III	Electronic Devices and Circuits Laboratory

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Power System Computational 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. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	Construct Y bus, Z bus for a n bus system and analyze various load flow studies.
II	Understand the steady state, transient stability analysis and economic load dispatch problem.
III	State estimation of power system and unit commitment problem.

VII COURSE OUTCOMES:

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

CO 1	**Understand** the concept of Admittance matrix for the formulation of various inspection and transformation methods.	Understand
CO 2	**Develop** the programming for load flow algorithms.	Apply
CO 3	**Analyze** the characteristics of fast decoupled loaf flow methods for developing algorithm.	Analyze
CO 4	**Categorize** the transient and short circuit analysis for analysing the performance of the system.	Apply
CO 5	**Categorize** the transient and short circuit analysis for analysing the performance of the system.	Analyze
CO 6	**Analyze** the various iterative methods applicable for state estimation of the power system.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL

VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	3	Lab Exercises
PO 2	An ability to write and present a substantial technical report / document..	3	Lab Exercises
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.	3	Lab Exercises
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	3	Lab Exercises
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment..	2	Lab Exercises
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X 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
CO 1	3	3	-	3	2	2

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

XI ASSESSMENT METHODOLOGY DIRECT:

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

XII ASSESSMENT METHODOLOGY INDIRECT:

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

XIII SYLLABUS:

WEEK I	**FORMATION OF BUS ADMITTANCE MATRIX**
	Develop program for Ybusformation by direct inspection method..
WEEK II	**SINGULAR TRANSFORMATION**
	Develop program for Ybus formation by singular transformation method.
WEEK III	**GAUSS - SEIDAL LOAD FLOW METHOD**
	Develop program for G-S load flow algorithm.
WEEK IV	**NEWTON - RAPHSON LOAD FLOW METHOD**
	Develop program for N-R load flow algorithm in polar coordinates.
WEEK V	**FAST DECOUPLED LOAD FLOW METHOD**
	Develop program for FDLF algorithm
WEEK VI	**DC LOAD FLOW**
	Develop program for DC load flow algorithm.
WEEK VII	**BUILDING ALGORITHM**
	Develop Program for ZBUS building algorithm.
WEEK VIII	**SHORT CIRCUIT ANALYSIS**
	Develop program for short circuit analysis using ZBUS algorithm.
WEEK IX	**TRANSIENT STABILITY**
	Develop program for transient stability analysis for single machine connected to infinite bus.

WEEK X	**LOAD DISPATCH PROBLEM**
	Develop program for economic load dispatch problem using lambda iterative method.
WEEK XI	**DYNAMIC PROGRAMMING METHOD**
	Develop program for unit commitment problem using forward dynamic programming method.
WEEK XII	**STATE ESTIMATION**
	Develop program for state estimation of power system.

TEXTBOOKS

1. 1. DP Kothari, B S Umre, "Lab manual for Electrical Machines", IK International Publishing House Pvt. Ltd, 1st Edition, 1996.

REFERENCE BOOKS:

1. MariesaLCrow, "Computational Methods for Electric Power Systems (Electric Power Engineering Series)", CRC Press Publishers, 1st Edition, 1992.

XIV 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	Develop program for Y-busformation by direct inspection method.	CO 1	T1:3.1
2	Develop program for Y-bus formation by singular transformation method.	CO 2	T1:3.11
3	Develop program for G-S load flow algorithm.	CO 3	T1:4.8
4	Develop program for N-R load flow algorithm in polar coordinates.	CO 2	T1:4.8
5	Develop program for FDLF algorithm.	CO 3	T1.5.5
6	Develop program for DC load flow algorithm.	CO 4	T1:5.6
7	Develop Program for Z-BUS building algorithm.	CO 4	T1:8.3
8	Develop program for short circuit analysis using ZBUS algorithm.	CO 5	T1:8.3
9	Develop program for transient stability analysis for single machine connected to infinite bus.	CO 3	T1:9.2
10	Develop program for economic load dispatch problem using lambda iterative method.	CO 5	T1:9.3
11	Develop program for unit commitment problem using forward dynamic programming method.	CO 3	T1:10.6
12	Develop program for state estimation of power system.	CO 6	T1:10.7

XV EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Develop program for Gaauss saidel load flow algorithm.
2	Develop program for Y-bus formation by singular transformation method
3	Develop program for short circuit analysis using Z-BUS algorithm.
4	Develop program for economic load dispatch problem using lambda iterative method
5	Develop program for state estimation of power system.

Signature of Course Coordinator **HOD,EEE**
Mr. P Shiva Kumar, Assistant Professor

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

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Digital Protection of Power System**				
Course Code	BPSC13				
Program	M.Tech				
Semester	II				
Course Type	Core				
Regulation	PG-21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr.P. Shiva kumar , Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEC22	VI	Power System Analysis
B.Tech	AEEC34	VII	Power system Protection

II COURSE OVERVIEW:

This course will provide the mathematical background of digital protection and understanding the importance of Digital Relays. It will also develop various protection algorithms. It will also cover the application of digital protection.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Digital Protection of Power System	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Seminars	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.

50%	To test the objectiveness of the concept
30%	To test the analytical skill of the concept
20%	To test the application skill of the concept

Continuous Internal Assessment (CIA):
For each theory course the CIA shall be conducted by the faculty / teacher handling the course. CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment / AAT shall be considered for computing the final CIA of a student in a given course.

The CIE Tests/Assignment /AAT shall be conducted by the course faculty with due approval from the HOD. Advance notification for the conduction of Assignment/AAT is mandatory and the responsibility lies with the concerned course faculty. CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Technical Seminar and Term Paper

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Assignment	AAT	
CIA Marks	20	5	5	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 9^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment:
To improve the writing skills in the course an assignment will be evaluated for 05 marks. One assignment has to submit at the end of the CIE2 for the questions provided by the each course coordinator in that semester. Assignments to be handed in as loose paper collection stapled together at the top left corner. The assignment should be presented as a professional report. It must consist of a cover sheet, content page, and should have an introduction, a body, a conclusion or recommendation, and a reference page.

Alternative Assessment Tool (AAT)
In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). This AAT enables faculty to design own assessment patterns during the CIA. The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. If properly applied, the AAT converts the classroom into an effective learning center.**The AAT may includes, concept videos, course related term paper, technical seminar, term paper, paper presentations conducted by reputed organizations relevant to the course etc.**

VI COURSE OBJECTIVES:

The students will try to learn:

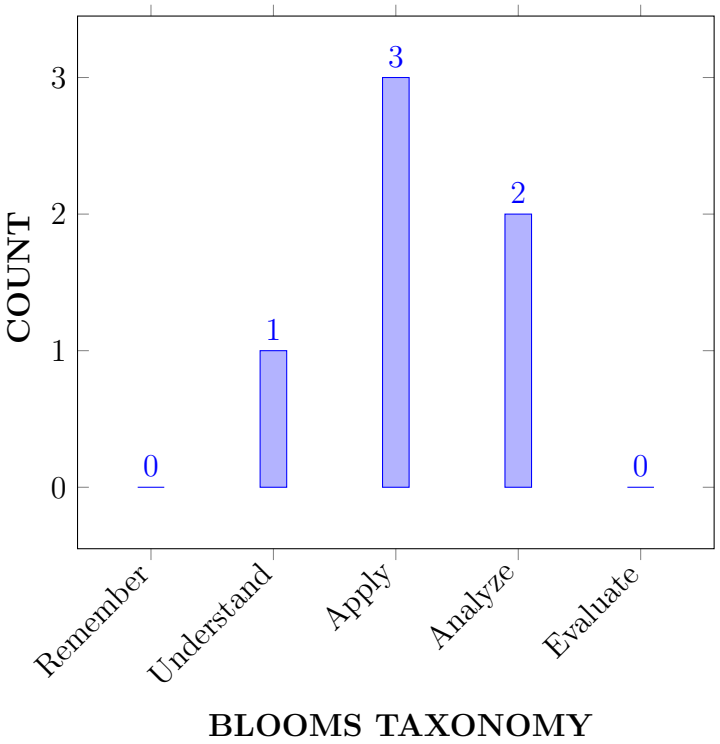
I	The need of numerical relays and their importance in digital protection of the power system.
II	The mathematical approach towards designing algorithms for the protection of power system.
III	The methods of protection employed for the transformers and transmission lines.

VII COURSE OUTCOMES:

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

CO 1	**Illustrate** the significance of protection systems and elements involved in protection of the power system.	Understand
CO 2	**Develop** the structures, mathematical models and formulae of digital relays for mathematical analysis of the system.	Apply
CO 3	**Identify** the basic components of digital relay and signal conditioning subsystems for implementation of digital protection.	Apply
CO 4	**Develop** the mathematical models for analysis of the relying algorithms to address the various types of faults in the power system.	Apply
CO 5	**Categorize** the digital relying algorithms to minimize the transient deviations and steady state error to zero	Analyze
CO 6	**Analyze** the various algorithms applicable for protection of Transformers and transmission lines.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	3	CIE/AAT/SEE
PO 2	An ability to write and present a substantial technical report / document.	2	CIE/AAT/SEE
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.	1	CIE/AAT/SEE
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	1	CIE/AAT/SEE
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	1	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	-	-	-	-
CO 2	✓	✓	✓	-	-	-
CO 3	✓	✓	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 4	✓	✓	-	-	-	-
CO 5	✓	✓	-	✓	-	✓
CO 6	✓	✓	-	✓	-	✓

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 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
CO 2	PO 2	**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 3	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 4	**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
CO 3	PO 2	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 4	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**.	
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 switched mode regulators	6
CO 5	PO 2	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 5	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
CO 6	PO 2	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 5	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 6	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

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

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

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	75	56	-	-	-	-
CO 2	75	56	56	-	-	-
CO 3	75	56	-	-	-	-
CO 4	75	56	-		-	-
CO 5	75	56	-	28	-	20
CO 6	75	56	-	28	-	20

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					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	2	-	-	-	-
CO 2	3	2	2	-	-	-
CO 3	3	2	-	-	-	-
CO 4	3	2	-	1	-	-
CO 5	3	2	-	1	-	-
CO 6	3	2	-	1	-	1
TOTAL	18	12	2	3	-	1
AVERAGE	3	2	1	1	-	1

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminar and term paper	-
Laboratory Practices	-	Student Viva	-	Mini Project	-

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	**End Semester OBE Feed Back**

XVII SYLLABUS:

MODULE I	**MATHEMATICAL BACKGROUND TO DIGITAL PROTECTION**
	Overview of static relays, transmission line protection, transformer protection, need for digital protection; performance and operational characteristics of digital protection, basic structure of digital relays, finite difference techniques, interpolation formulas, numerical differentiation, curve fitting and smoothing, Fourier analysis, Walsh function analysis, relationship between Fourier and Walsh coefficients
MODULE II	**BASIC ELEMENTS OF DIGITAL PROTECTION**
	Basic components of a digital relay, signal conditioning subsystems, conversion subsystem, digital relay subsystem, the digital relay as a unit
MODULE III	**DIGITAL RELAYING ALGORITHMS-I**
	Sinusoidal wave-based algorithms: Sample and first derivative methods, first and second derivative methods, two sample technique, three sample technique, an early relaying scheme. Fourier analysisbased algorithms: Full cycle window algorithm, fractional-cycle window algorithms, Fouriertransform based algorithm. Walsh-function-based algorithms. Unbalanced faults: Introduction to symmetrical components, sequence impedances, sequence circuits of synchronous machine, transformer and transmission lines, sequence networks analysis of single line to ground, line to line and double line to ground faults using Thevenin's theorem and Z-bus matrix.
MODULE IV	**DIGITAL RELAYING ALGORITHMS-II**
	Least squares based methods: Integral LSQ fit, power series LSQ fit, multi-variable series LSQ technique, determination of measured impedance estimates; differential equation based techniques: representation of transmission lines with capacitance neglected, differential equation protection with selected limits, simultaneous differential equation techniques; travelling-wave based protection: fundamentals of travelling-wave based protection, Bergeron's-equation based protection scheme, ultra-high-speed polarity comparison scheme, ultra-high-speed wave differential scheme, discrimination function based scheme, superimposed component trajectory based scheme.

MODULE V	**DIGITAL PROTECTION OF TRANSFORMERS AND TRANSMISSION LINES**
	Principles of transformer protection, digital protection of Transformer using FIR filter-based algorithm, least squares curve fitting based algorithms, Fourier-based algorithm, flux-restrained current differential relay; Digital Line differential protection: Current-based differential schemes, Composite voltage- and current- based scheme.

TEXTBOOKS

1. AG Phadke and J S Thorp, "Computer Relaying for Power Systems", Wiley/Research studies Press, 1st Edition, 2009.
2. AT Johns and S K Salman, "Digital Protection of Power Systems", IEEE Press, 1st Edition, 1999

REFERENCE BOOKS:

1. Gerhard Zeigler, "Numerical Distance Protection", Siemens Public Corporate Publishing, 1st Edition, 2006.
2. SRB hide "Digital Power System Protection" PHI Learning Pvt.Ltd. 3rd Edition, 2014

WEB REFERENCES:

1. . https://www.sciencedireect.com
2. https://www.spinger.com
3. https://www.ieeexplore.ieee.org/Xplore/home.jsp

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 Description on Outcome Based Education (OBE)		
CONTENT DELIVERY (THEORY)			
1	Overview of static relays, transmission line protection	CO1	T1: 1.1
2	Basic Concept of transformer protection	CO1	T1: 1.2
3	Need for digital protection; performance and operational characteristics of digital protection,	CO1	T2: 1.1.1
4	basic structure of digital relay	CO1	T2: 1.3.1
5	finite difference techniques, interpolation formulas, numerical differentiation,	CO1	T2: 1.3.3
6	Discuss the Concept of curve fitting and smoothing	CO1	T1: 1.3.2
7	Discuss the Concept of curve fitting and smoothing	CO1	T1: 1.3.2
8	Discuss about Fourier Analysis	CO2	T2: 1.3.8
9	Walsh function analysis, relationship between Fourier and Walsh coefficients	CO2	T1: 2.1
10	Walsh function analysis, relationship between Fourier and Walsh coefficients	CO2	T1: 2.1

11	Basic components of a digital relay	CO3	T3: 5.2
12	Discuss about signal conditioning subsystems	CO3	T1: 5.7
13	Discuss about conversion subsystem	CO3	T3: 5.7
14	Discuss about digital relay subsystem	CO3	T2: 5.7
15	Discuss about the digital relay as a module	CO3	T3: 5.7
16	Discuss about Sinusoidal wave-based algorithms	CO4	T1: 9.1
17	Discuss about Sample and first derivative methods,	CO4	T1: 9.1
18	Discuss about first and second derivative methods	CO4	T1: 9.1
19	Discuss about two sample technique, three sample technique, an early relaying scheme.	CO4	T1: 9.1
20	Discuss about Fourier analysis-based algorithms	CO4	T1: 9.1
21	Discuss about Full cycle window algorithm	CO4	T1: 6.2
22	Discus about fractional-cycle window algorithms	CO4	T1: 7.1
23	Discus about Fourier- transform based algorithm	CO4	T3: 5.7
24	Discus about Walsh-function-based algorithms.	CO4	T2: 5.7
25	Least Squares Based Methods: Integral LSQ fit, power series lsq fit, multi-variable series lsq technique	CO5	T1: 5.7
26	Least Squares Based Methods: Integral LSQ fit, power series lsq fit, multi-variable series lsq technique	CO5	T1: 5.7
27	Discuss about determination of measured impedance estimates and differential equation-based techniques	CO5	T1: 2.2
28	Discuss about representation of transmission lines with capacitance neglected	CO5	T1: 2.3
29	Discuss about differential equation protection with selected limits, simultaneous differential equation techniques	CO5	T1: 5.7
30	travelling-wave based protection: fundamentals of travelling-wave based protection, Bergeron's- equation based protection Scheme, Ultra-high-speed polarity Comparison scheme,	CO5	T2: 2.1
31	travelling-wave based protection: fundamentals of travelling-wave based protection, Bergeron's- equation based protection Scheme, Ultra-high-speed polarity Comparison scheme,	CO5	T2: 2.1
32	Discuss about Ultra-high-speed wave differential scheme	CO5	T1: 5.7
33	Discuss about discrimination function-based scheme	CO6	T1: 2.2
34	Discuss about Sample and first derivative methods,	CO4	T1: 9.1
35	Discuss about first and second derivative methods	CO4	T1: 9.1
36	Discuss about two sample technique, three sample technique, an early relaying scheme.	CO4	T1: 9.1
37	Discuss about Fourier analysis-based algorithms	CO4	T1: 9.1
38	Discuss about Full cycle window algorithm	CO4	T1: 6.2
39	Discus about fractional-cycle window algorithms	CO4	T1: 7.1
40	Discus about Fourier- transform based algorithm	CO4	T3: 5.7
41	Discus about Walsh-function-based algorithms.	CO4	T2: 5.7
42	Least Squares Based Methods: Integral LSQ fit, power series lsq fit, multi-variable series lsq technique	CO5	T1: 5.7

43	Least Squares Based Methods: Integral LSQ fit, power series lsq fit, multi-variable series lsq technique	CO5	T1: 5.7
44	Discuss about determination of measured impedance estimates and differential equation-based techniques	CO5	T1: 2.2
45	Discuss about representation of transmission lines with capacitance neglected	CO5	T1: 2.3
46	Discuss about differential equation protection with selected limits, simultaneous differential equation techniques	CO5	T1: 5.7
47	travelling-wave based protection: fundamentals of travelling-wave based protection, Bergeron's- equation based protection Scheme, Ultra-high-speed polarity Comparison scheme,	CO5	T2: 2.1
48	travelling-wave based protection: fundamentals of travelling-wave based protection, Bergeron's- equation based protection Scheme, Ultra-high-speed polarity Comparison scheme,	CO5	T2: 2.1
49	Discuss about Ultra-high-speed wave differential scheme	CO5	T1: 5.7
50	Discuss about discrimination function-based scheme	CO6	T1: 2.2
51	Discuss about superimposed component trajectory-based Scheme	CO6	T1: 2.2
52	Discuss about superimposed component trajectory-based Scheme	CO6	T1: 2.2
53	Discuss about Principles of transformer protection	CO6	T1: 2.3
54	Discuss about Principles of transformer protection	CO6	T1: 2.3
55	Discuss about superimposed component trajectory-based Scheme	CO6	T1: 2.2
56	Discuss about superimposed component trajectory-based Scheme	CO6	T1: 2.2
57	Discuss about Principles of transformer protection	CO6	T1: 2.3
58	Discuss about Principles of transformer protection	CO6	T1: 2.3
59	Discuss about digital protection of Transformer using FIR filter-based algorithm	CO6	T1: 9.1
60	Discuss about least squares curve fitting based algorithms	CO5	T1: 6.2
DISCUSSION OF QUESTION BANK			
1	Mathematical Background To Digital Protection	CO1 CO2	-
2	Basic Elements Of Digital Protection	CO3	-
3	Digital Relaying Algorithms-I	CO4 -	
45	Digital Relaying Algorithms-II	CO5	-
5	Digital Protection Of Transformers And Transmission Lines	CO6	-

Signature of Course Coordinator **HOD,EEE**
Mr.P. Shiva kumar , Assistant Professor

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

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**POWER SYSTEM DYNAMICS AND STABILITY**				
Course Code	BPSC14				
Program	M.Tech				
Semester	II				
Course Type	Professional Core				
Regulation	PG-21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	-	-
Course Coordinator	Dr. VC Jagan Mohan, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEC22	VI	Power System Analysis
B.Tech	AEEC34	VII	Power system Protection

II COURSE OVERVIEW:

Power system analysis deals formation impedance and admittance matrices for power system network, finding different electrical parameters for various buses in power system, study fault analysis and represent power system using per unit system, understand steady state and transient stability of power system.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Modern Power System Analysis	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Seminars	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.

50%	To test the objectiveness of the concept
30%	To test the analytical skill of the concept
20%	To test the application skill of the concept

Continuous Internal Assessment (CIA):
For each theory course the CIA shall be conducted by the faculty / teacher handling the course. CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment / AAT shall be considered for computing the final CIA of a student in a given course.

The CIE Tests/Assignment /AAT shall be conducted by the course faculty with due approval from the HOD. Advance notification for the conduction of Assignment/AAT is mandatory and the responsibility lies with the concerned course faculty. CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Technical Seminar and Term Paper

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Assignment	AAT	
CIA Marks	20	5	5	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 9^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment:
To improve the writing skills in the course an assignment will be evaluated for 05 marks. One assignment has to submit at the end of the CIE2 for the questions provided by the each course coordinator in that semester. Assignments to be handed in as loose paper collection stapled together at the top left corner. The assignment should be presented as a professional report. It must consist of a cover sheet, content page, and should have an introduction, a body, a conclusion or recommendation, and a reference page.

Alternative Assessment Tool (AAT)
In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). This AAT enables faculty to design own assessment patterns during the CIA. The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. If properly applied, the AAT converts the classroom into an effective learning center.**The AAT may includes, concept videos, course related term paper, technical seminar, term paper, paper presentations conducted by reputed organizations relevant to the course etc.**

VI COURSE OBJECTIVES:

The students will try to learn:

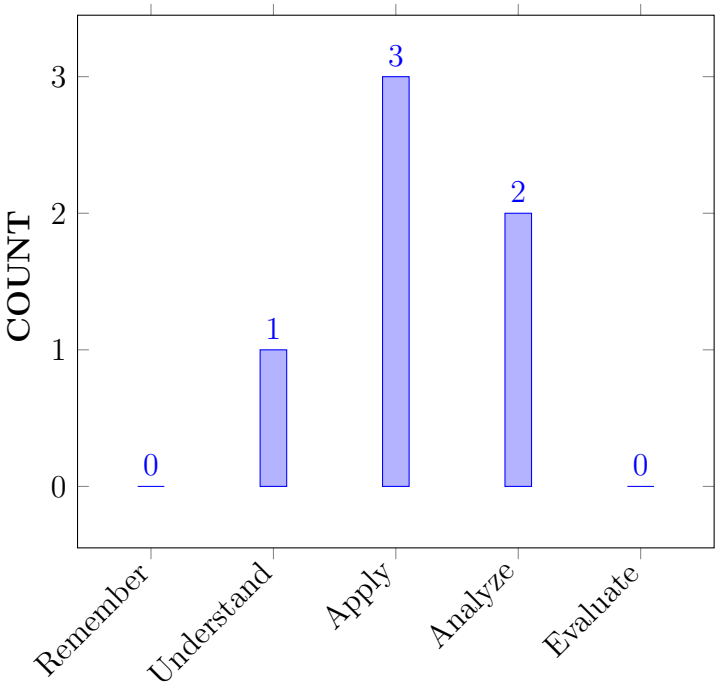
I	Mathematical models for synchronous machine, Exciter, Governor and Prime mover.
II	Power system dynamic phenomena and the effects of exciter and governor control.
III	The methods to improve dynamic stability.

VII COURSE OUTCOMES:

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

CO 1	**Illustrate** the significance of power system stability and approach for analysis of multi machine system.	Understand
CO 2	**Develop** the state space equations, unit conversions, equivalent circuits for mathematical analysis of the synchronous machines.	Apply
CO 3	**Develop** the basic components of digital relay and signal conditioning subsystems for implementation of digital protection.	Apply
CO 4	**Identify** the types of excitation and voltage control configurations to address the effects of voltage changes and reactive power.	Apply
CO 5	**Illustrate** the significance of governing system for excitation and prime mover control.	Analyze
CO 6	**Explain** the methods to enhance the small signal stability of the power system.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	Independently carry out research / investigation and development work to solve practical problems.
PO 2	Write and present a substantial technical report / document.
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skillfulatdesigningembeddedsystemsforeffectiveuseincommunications, IoT, medical electronics and signal processing applications.
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	Independently carry out research / investigation and development work to solve practical problems.	2	AAT/SEE/CIE
PO 2	Write and present a substantial technical report / document.	2	AAT/SEE/CIE
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.	2.5	AAT/SEE/CIE
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	3	AAT/SEE/CIE
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.	1	AAT/SEE/CIE
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	2	AAT/SEE/CIE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	✓	✓	-	-	-
CO 2	✓	-	✓	✓	-	-
CO 3	-	✓	✓	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 4	✓	-	✓	✓	-	✓
CO 5	-	-	✓	-	✓	-
CO 6	-	-	✓	✓	-	✓

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 matched.
CO 1	PO 3	Demonstrate the importance of embedded technologies and design new innovative products for solving society relevant problems for applying knowledge, understanding and demonstrations of embedded applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate electively in writing / orally societal problems.	4
	PO 4	Apply the concepts (knowledge) of embedded systems using their architectures by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations such as IoT and Robotics and use creativity to establish the solutions and make the experimental design.	5
CO 2	PO 3	Demonstrate the importance of embedded technologies and design new innovative products for solving society relevant problems for applying knowledge, understanding and demonstrations of embedded applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate electively in writing / orally societal problems.	6
	PO 4	Apply the concepts (knowledge) of embedded systems using their architectures by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations such as IoT and Robotics and use creativity to establish the solutions and make the experimental design.	5
CO 3	PO 3	Demonstrate the importance of embedded technologies and design new innovative products for solving society relevant problems for applying knowledge, understanding and demonstrations of embedded applications in real time scenario and use creativity to establish innovative solutions and manage the design process and evaluate outcomes using modern tools to get the solution development and communicate electively in writing / orally societal problems. science and engineering fundamentals.	5

CO 4	PO 4	Apply the concepts (knowledge) of embedded systems using their architectures by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations such as IoT and Robotics and use creativity to establish the solutions and make the experimental design.	5
	PO 3	Demonstrate the importance of embedded technologies and design new innovative products for solving society relevant problems for applying knowledge, understanding and demonstrations of embedded applications in real time scenario and use creativity to establish innovative solutions and manage the design process and evaluate outcomes using modern tools to get the solution development and communicate electively in writing / orally societal problems. science and engineering fundamentals.	5
CO 5	PO 4	Apply the concepts (knowledge) of embedded systems using their architectures by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations such as IoT and Robotics and use creativity to establish the solutions and make the experimental design.	5
	PO 6	Recognize the need to engage in lifelong learning through continuing education and research for strengthen in embedded and advanced engineering areas.	1
	PO 3	Demonstrate the importance of embedded technologies and design new innovative products for solving society relevant problems for applying knowledge, understanding and demonstrations of embedded applications in real time scenario and use creativity to establish innovative solutions and manage the design process and evaluate outcomes using modern tools to get the solution development and communicate electively in writing / orally societal problems. science and engineering fundamentals.	5
	PO 4	Apply the concepts (knowledge) of embedded systems using their architectures by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations such as IoT and Robotics and use creativity to establish the solutions and make the experimental design.	5
	PO 6	Recognize the need to engage in lifelong learning through continuing education and research for strengthen in embedded and advanced engineering areas.	1

CO 6	PO 3	Demonstrate the importance of embedded technologies and design new innovative products for solving society relevant problems for applying knowledge, understanding and demonstrations of embedded applications in real time scenario and use creativity to establish innovative solutions and manage the design process and evaluate outcomes using modern tools to get the solution development and communicate electively in writing / orally societal problems. science and engineering fundamentals.	5
	PO 4	Apply the concepts (knowledge) of embedded systems using their architectures by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations such as IoT and Robotics and use creativity to establish the solutions and make the experimental design.	5

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

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

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	43	100	-	-	-
CO 2	50	-	80	80	-	-
CO 3	-	57	80	-	-	-
CO 4	50	-	75	80	-	60
CO 5	-	-	80	-	65	-
CO 6	-	-	80	73	-	60

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					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	2	2	-	-	-
CO 2	2	-	3	3	-	-
CO 3	-	2	2	-	-	
CO 4	2	-	2	3	-	2
CO 5	-	-	2	-	1	
CO 6	-	-	3	3	-	2
TOTAL	4	4	15	9	1	4
AVERAGE	2	2	2.5	3	1	2

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminar and term paper	-
Laboratory Practices	-	Student Viva	-	Mini Project	-

✓	**End Semester OBE Feed Back**

XVI SYLLABUS:

MODULE I	**POWER SYSTEM STABILITY: A CLASSICAL APPROACH**
	Introduction, requirements of a reliable electrical power service, swing equation, power-angle curve, stability analysis of SMIB system, equal area criteria, classical model of a multi-machine system, shortcomings of the classical model, block diagram of one machine, system response to small disturbances: types of problems studied, the unregulated synchronous machine, modes of oscillation of an unregulated multi-machine system, regulated synchronous machine.
MODULE II	**SYNCHRONOUS MACHINE MODELING-I**
	Introduction, Park's Transformation, flux linkage equations, voltage equations, formulation of state- space equations, current formulation, per unit conversion, normalizing the voltage and torque equations, equivalent circuit of a synchronous machine, the flux linkage state-space model, load equations, sub-transient and transient inductances and time constants, simplified models of the synchronous machine, turbine generator dynamic models.
MODULE III	**SYNCHRONOUS MACHINE MODELING -III**
	Steady state equations and phasor diagrams, determining steady state conditions, evaluation of initial conditions, determination of machine parameters. Digital simulation of synchronous machines, linearization and simplified linear model and state-space representation of simplified model.

MODULE IV	**EXCITATION AND PRIME MOVER CONTROL**
	Simplified view of excitation control, control configurations, typical excitation configurations, excitation control system definitions, voltage regulator, exciter buildup, excitation system response, state-space description of the excitation system, computer representation of excitation systems, typical system constants, and the effects of excitation on generator power limits, transient stability and dynamic stability of the power system; Prime mover control: Hydraulic turbines and governing systems, steam turbines and governing systems.
MODULE V	**SMALL SIGNAL STABLITY ANALYSIS**
	Fundamental concepts of stability of dynamic systems, Eigen properties of the state matrix, small-signal stability of a single-machine infinite bus system, effects of excitation system, power system stabilizer, system state matrix with amortizes, characteristics of small-signal stability problems.

TEXTBOOKS

1. 1. P M Anderson & A A Fouad "Power System Control and Stability", Galgotia, New Delhi, 1st Edition.
2. 2. J Machowski, J Bialek& J R W Bumby, "Power System Dynamics and Stability", John Wiley &Sons, 1st Edition.

REFERENCE BOOKS:

1. 1. P Kundur, "Power System Stability and Control", McGraw Hill Inc., 1st Edition.
2. 2. E WKimbark,"Powersystemstability",Vol.I&III,JohnWiley&Sons,NewYork1st Edition, 2002
3. 3. L Leonard Grigsby (Ed.); "Power System Stability and Control", Second edition, CRC Press, 1st Edition.

WEB REFERENCES:

1. .http://www.nptelvideos.in/2012/11/embedded-systems.html

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 T1: 4.1
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE)		
CONTENT DELIVERY (THEORY)			
1	Introduction, requirements of a reliable electrical power service,	CO 1	T4:9.41, R1:3.1-3.2
2	Introduction, requirements of a reliable electrical power service,	CO 1	T4:9.41, R1:3.1-3.2
3	Swing equation, power-angle curve,	CO 1	T4:9.4.1, R1:3.1-3.2

4	Swing equation, power-angle curve,	CO 1	T4:9.4.1, R1:3.1-3.2
5	stability analysis of SMIB system, equal area criteria,	CO 1	T4:9.4.3, R1:3.3-3.5
6	stability analysis of SMIB system, equal area criteria,	CO 1	T4:9.4.3, R1:3.3-3.5
7	Classical model of a multi-machine system, shortcomings of the classical model,	CO1	T4:9.2, R1:3.3-3.5
8	Classical model of a multi-machine system, shortcomings of the classical model,	CO1	T4:9.2, R1:3.3-3.5
9	Block diagram of one machine, system response to small disturbances: types of problems studied,	CO 1	T4:9.2, R1:3.3-3.5
10	Block diagram of one machine, system response to small disturbances: types of problems studied,	CO 1	T4:9.2, R1:3.3-3.5
11	The unregulated synchronous machine, modes of oscillation of an unregulated multi-machine system,	CO 1	T4:9.2, R1:3.3-3.5
12	The unregulated synchronous machine, modes of oscillation of an unregulated multi-machine system,	CO 1	T4:9.2, R1:3.3-3.5
13	Regulated synchronous machine.	CO 1	T4:9.4, R1:4.1
14	Regulated synchronous machine.	CO 1	T4:9.4, R1:4.1
15	Introduction, Park's Transformation,	CO 2	T4:9.3-9.5, R1:4.2
16	Introduction, Park's Transformation,	CO 2	T4:9.3-9.5, R1:4.2
17	Flux linkage equations, voltage equations,	CO 2	T4: 9.3-9.5, R1:4.3-4.4
18	Flux linkage equations, voltage equations,	CO 2	T4: 9.3-9.5, R1:4.3-4.4
19	Formulation of state- space equations, current formulation,	CO 2	T4: 9.3-9.5, R1:4.3-4.4

20	Formulation of state- space equations, current formulation,	CO 2	T4: 9.3-9.5, R1:4.3-4.4
21	Per unit conversion, normalizing the voltage and torque equations,	CO 2	T4:9.1, R1:8.1
22	Per unit conversion, normalizing the voltage and torque equations,	CO 2	T4:9.1, R1:8.1
23	Equivalent circuit of a synchronous machine, the flux linkage state-space model,	CO 2	T4:9.8, R1:8.2
24	Equivalent circuit of a synchronous machine, the flux linkage state-space model,	CO 2	T4:9.8, R1:8.2
25	load equations, sub-transient and transient inductances and time constants,	CO 2	T4:9.9.1, R1:9.2
26	load equations, sub-transient and transient inductances and time constants,	CO 2	T4:9.9.1, R1:9.2
27	Simplified models of the synchronous machine, turbine generator dynamic models.	CO 2	T4:9.8, R1:9.2
28	Simplified models of the synchronous machine, turbine generator dynamic models.	CO 2	T4:9.8, R1:9.2
29	Steady state equations and phasor diagrams, determining steady state conditions,	CO 3	T4:9.10, R1:9.2
30	Steady state equations and phasor diagrams, determining steady state conditions,	CO 3	T4:9.10, R1:9.2
31	Evaluation of initial conditions, determination of machine parameters.	CO 3	T4:9.11.2, R1:9.2
32	Evaluation of initial conditions, determination of machine parameters.	CO 3	T4:9.11.2, R1:9.2
33	Simplified view of excitation control, control configurations,	CO 4	T4:9.12, R1:9.2
34	typical excitation configurations, excitation control system definitions,	CO 4	T4:9.4.12, R1:9.2
35	voltage regulator, exciter buildup, excitation system response,.	CO 3	T4:10.3, R1:6.1-6.3
36	state-space description of the excitation system, computer representation of excitation systems,	CO 4	T4:10.4, R1:6.4
37	state-space description of the excitation system, computer representation of excitation systems,	CO 4	T4:10.4, R1:6.4
38	typical system constants, and the effects of excitation on generator power limits,	CO 4	T4:10.5, R1:6.4
39	typical system constants, and the effects of excitation on generator power limits,	CO 4	T4:10.5, R1:6.4
40	transient stability and dynamic stability of the power system;	CO 4	T4:10.6, R1:6.3

41	Prime mover control: Hydraulic turbines and governing systems, steam turbines and governing systems.Short Circuit Analysis: Short Circuit Current and MVA CalculationsSolving numerical problems (Symmetrical fault Analysis).	CO 4	T4:10.7, R1:6.3
42	Prime mover control: Hydraulic turbines and governing systems, steam turbines and governing systems.Short Circuit Analysis: Short Circuit Current and MVA CalculationsSolving numerical problems (Symmetrical fault Analysis).	CO 4	T4:10.7, R1:6.3
43	Fundamental concepts of stability of dynamic systems, Eigen properties of the state matrix,	CO 5	T4:10.5, R1:6.3
44	Small-signal stability of a single-machine infinite bus system, effects of excitation system,	CO 5	T4:10.13, R1:6.3
45	Small-signal stability of a single-machine infinite bus system, effects of excitation system,	CO 5	T4:10.13, R1:6.3
46	Power system stabilizer, system state matrix with amortizes, characteristics of small-signal stability problems.	CO 5	T4:10.13, R1:6.1-6.3
47	Determine LLG fault with and without fault impedance and numerical problems.	CO 5	T4:10.16, R1:6.1-6.3
48	Compare LG, LL, LLG faults with and without fault impedance and numerical problems.	CO 5	T4:10.17, R1:6.1-6.3
49	Introduction to steady state, dynamic and transient stabilities.	CO 5	T4:13.1, R1:10.1
50	Description of steady state stability power limit, transfer reactance, synchronizing power coefficient.	CO 5	T4:13.2, R1:10.3
51	Plot Power Angle Curve and determination of steady state,. stability.	CO 5	T4:13.2, R1:6.4
52	Explain methods to improve steady state stability.	CO 5	T4:13.2, R1:10.3
53	Derivation of swing equation.	CO 8	T4:13.3, R1:10.2
54	Determination of transient stability by equal area criterion.	CO 5	T4:13.6, R1:10.5
55	Application of equal area criterion to different cases.	CO 5	T4:13.7, R1:10.5
56	Discuss importance of critical clearing angle calculation.	CO 5	T4:13.6, R1:10.5
57	Solving numerical problems on equal area criteria.	CO 5	T4:13.7, R1:10.5
58	Solution of swing equation: point-by- point method.	CO 5	T4:13.7, R1:10.5
59	Solution of swing equation: point-by- point method.	CO 5	T4:13.7, R1:10.5
60	Solution of swing equation: point-by- point method.	CO 5	T4:13.7, R1:10.5

DISCUSSION OF QUESTION BANK			
1	Power System Stabilit and Classical Apporach	CO1, CO2	T1: 2.1
2	Synchronous machine modeling-I	CO3	T1: 3.2
3	Synchronous machine modeling-II	CO4	T1: 4.2
4	Excitation and Prime Mover Control	CO5	T1: 5.2
5	Small Signal Stability Analysis	CO6	T1: 6.2

Signature of Course Coordinator **HOD,EEE**
Dr VC Jagan Mohan, Associate Professor

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

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**INDUSTRIAL LOAD MODELLING AND CONTROL**				
Course Code	BPSC16				
Program	M.Tech				
Semester	II				
Course Type	Professional Elective				
Regulation	PG-21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. Puppala Rajendhar,Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB34	V	Electrical Energy Conservation and Auditing
B.Tech	AEEB52	VI	Industrial Electrical System

II COURSE OVERVIEW:

Industrial load modeling and control analysis deals with Electrical energy scenario of Demand and load side management, Optimization and control algorithms and reactive power management of direct and interruptible load control, load profiling of cooling and heating loads and cool storage and control strategies , problem formulation, Describe capacitive power units and power pooling, Illustrate optimal operating and control strategies of optimal operating condition and load management for industries.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Industrial Load Modelling and Control	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	**x**	MOOC
x	Seminars	**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.

50%	To test the objectiveness of the concept
30%	To test the analytical skill of the concept
20%	To test the application skill of the concept

Continuous Internal Assessment (CIA):
For each theory course the CIA shall be conducted by the faculty / teacher handling the course. CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment / AAT shall be considered for computing the final CIA of a student in a given course.

The CIE Tests/Assignment /AAT shall be conducted by the course faculty with due approval from the HOD. Advance notification for the conduction of Assignment/AAT is mandatory and the responsibility lies with the concerned course faculty. CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Technical Seminar and Term Paper

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Assignment	AAT	
CIA Marks	20	5	5	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 9^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment:
To improve the writing skills in the course an assignment will be evaluated for 05 marks. One assignment has to submit at the end of the CIE2 for the questions provided by the each course coordinator in that semester. Assignments to be handed in as loose paper collection stapled together at the top left corner. The assignment should be presented as a professional report. It must consist of a cover sheet, content page, and should have an introduction, a body, a conclusion or recommendation, and a reference page.

Alternative Assessment Tool (AAT)
In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). This AAT enables faculty to design own assessment patterns during the CIA. The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. If properly applied, the AAT converts the classroom into an effective learning center.**The AAT may includes, concept videos, course related term paper, technical seminar, term paper, paper presentations conducted by reputed organizations relevant to the course etc.**

VI COURSE OBJECTIVES:

The students will try to learn:

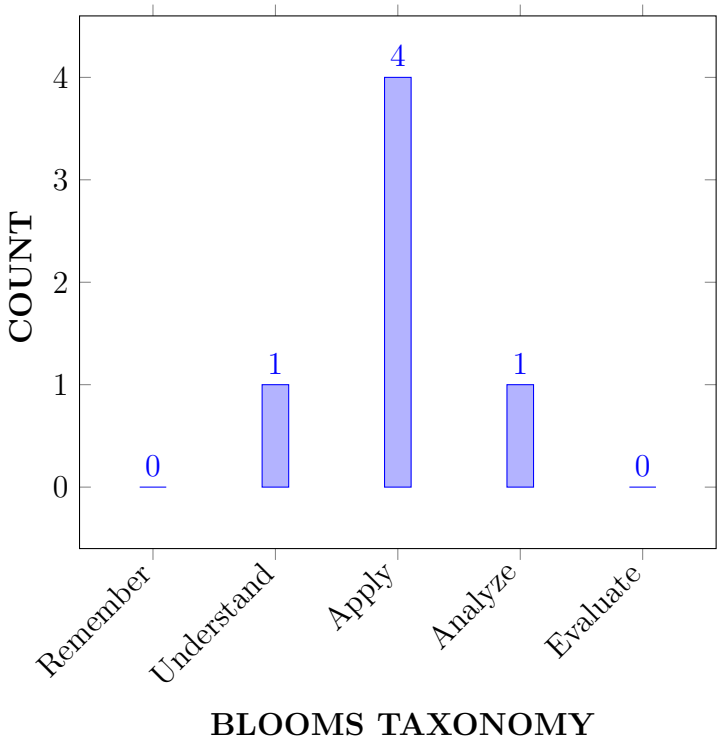
I	The Electric Energy Scenario - industrial load management and their implementation through various classical methods.
II	The necessity and power quality improvements of generation, transmission and distribution of electrical power for energy saving in industries.
III	The concepts of captive power units its operation, power pooling and industrial cogeneration with characteristics for real-world engineering problems and applications.
IV	The optimal operating strategies required on the system to meet the minute-tominute variation of system demand and its significance in power system operation and control by maintaining the frequency and voltage as constant.

VII COURSE OUTCOMES:

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

CO 1	**Apply** knowledge of engineering science including electrical circuits, control systems and electrical machines in industrial load modelling and control.	Apply
CO 2	**Determine** the industrial load management in a power system supply specific amount of demand.	Understand
CO 3	**Outline** the interruptible load control, Direct load control, controls power quality impacts for minimising transmission line losses and energy saving in industries.	Apply
CO 4	**Analyze** the cooling and heating loads, cool storage, control strategies in an industrial power system.	Analyze
CO 5	**Design** a capacitive power unit in industrial load for imparting knowledge of various controllers with its evolution, principle of operation and applications.	Apply
CO 6	**Determine** the optimal operating strategies of power capacitors for integrated load management and industries with economic justification.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	2	CIE/AAT/SEE
PO 2	An ability to write and present a substantial technical report / document.	1	CIE/AAT/SEE
PO 3	Student should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.	2	CIE/AAT/SEE

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	2	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	✓	✓	-	-
CO 2	-	✓	✓	✓	-	-
CO 3	✓	✓	✓	✓	-	-
CO 4	-	-	✓	✓	-	-
CO 5	-	-	-	✓	-	-
CO 6	-	-	✓	✓	-	-

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 matched.
CO 1	PO 3	Understand the concept of industrial load and analyze and design innovative models to establish innovative solution.	3
	PO 4	Make use of industrial load management techniques in power systems using the concepts of engineering fundamentals to develop the solution of problem formulation and abstraction to establish innovative solutions for Interpretation of results and Validation .	3
CO 2	PO 2	Illustrate the conceptual knowledge of electrical power systems for real time power system applications and with effective communication skills.	2
	PO 3	Illustrate the conceptual knowledge of electrical power systems for real time power system applications and with effective communication skills.	3
	PO 4	Understand the concept of industrial load on modern-day issues of Power Systems like industrial load management using advanced technologies with a global perspective.	4
CO 3	PO 1	Demonstrate research areas to solve practical problems in power systems and build solutions	2
	PO 2	Illustrate the conceptual knowledge of electrical power systems for real time power system applications and with effective communication skills.	2

	PO 3	Contrast the design process to minimize transmission line losses and energy saving in industries in electrical power systems for Solution development or experimentation / Implementation in Interpretation of results and Validation	4
	PO 4	Understand the concepts of heating loads and their effect on power system for real time energy management and the design process.	3
CO 4	PO 3	Demonstrate energy consumption of industrial loads by understanding and analyzing and design innovative solutions and Apply the complex engineering problems and their system components by design for the development of solution.	3
	PO 4	Make use of captive power plants in power systems using the concepts of engineering fundamentals to develop the solution of problem formulation and abstraction to establish innovative solutions for Interpretation of results and Validation	4
CO 5	PO 4	Understand the concepts of heating loads and their effect on power system for real time energy management.	4
CO 6	PO 3	Demonstrate operating strategies of power capacitors for integrated load management forapplication and solution of the complex engineering problems for the development of solution.	3
	PO4	Make use of power capacitors in power systems using the concepts of engineering fundamentals to develop the solution of problems and establish innovative solutions.	3

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

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

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	42.8	42.8	-	-
CO 2	-	28.57	42.8	57.1	-	-
CO 3	50	28.57	57.1	42.8	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 4	-	-	42.8	57.1	-	-
CO 5	-	-	-	57.1	-	-
CO 6	-	-	42.8	42.8	-	-

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					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	2	2	-	-
CO 2	-	1	2	2	-	-
CO 3	2	1	2	2	-	-
CO 4	-	-	2	2	-	-
CO 5	-	-	-	2	-	-
CO 6	-	-	2	2	-	-
TOTAL	2	2	10	12	-	-
AVERAGE	2	1	2	2	-	-

XV 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	-	-	-	-	

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	**End Semester OBE Feed Back**

XVII SYLLABUS:

MODULE I	**ELECTRIC ENERGY SCENARIO**
	Electric Energy Scenario, demand side management, industrial load management, load curves, load shaping objectives, methodologies, barriers, classification of industrial loads, continuous and batch processes, load modeling.
MODULE II	**DIRECT LOAD CONTROL INTERRUPTIBLE LOAD CONTROL**
	Direct load control, interruptible load control, bottom up approach, scheduling, formulation of load models, optimization and control algorithms, case studies, reactive power management in industries, controls power quality impacts, application of filters, energy saving in industries.
MODULE III	**COOLING AND HEATING LOADS LOAD PROFILING**
	Cooling and heating loads, load profiling, modeling, cool storage, types. Control strategies, optimal operation, problem formulation, case studies.
MODULE IV	**CAPTIVE POWER UNITS**
	Captive power UNITs, operating and control strategies, power pooling, operation models, energy banking, industrial cogeneration.
MODULE V	**OPTIMAL OPERATING STRATEGIES**
	Selection of schemes, optimal operating strategies, peak load saving, constraints problem formulation, case study, integrated load management for industries.

TEXTBOOKS

1. CO Bjork "Industrial Load Management - Theory, Practice and Simulations", Elsevier, theNetherlands, 1st Edition, 1989.
2. CW Gellings and S NTalukdar, "Load management concepts," IEEE Press, New York, 2nd Edition,1986.

REFERENCE BOOKS:

1. Y. Manichaikul and F.C. Schweppe, "Physically based Industrial load", IEEE Trans. on PAS, 2nd Edition, 1981.
2. H. G. Stoll, "Least cost Electricity Utility Planning", Wiley Interscience Publication, USA, 2nd Edition, 1989
3. J.Nagarath and D P Kothari, .Modern Power System Engineering.,Tata McGraw Hill publishers, New Delhi, 1stEdition, 1995.
4. IEEE Bronze Book- "Recommended Practice for Energy Conservation and Cost Effective Planning in Industrial Facilities", IEEE Inc, USA.

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
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE)		
CONTENT DELIVERY (THEORY)			
1	Need for Electric Energy Scenario.	CO 1	T2:1.1,1.2
2	Basic demand side management.	CO 1	T2:1.3,1.4
3	Introduction to industrial load management.	CO 1	T2:1.5,1.6
4	Lload shaping objectives.	CO 1	T2:3.1
5	Per phase load shaping objectives	CO 1	T1:4.3 T2:5.2
6	Generator, methodologies	CO 2	T2:2.1
7	Generator, methodologies	CO 3	T2:2.1.3
8	Barriers	CO 2	T1:9.3-9.5, R1:4.2
9	Construction classification of industrial loads.	CO 3	T2: 9.3-9.5
10	Construction classification of industrial loads.	CO 3	R1:4.3-4.4
11	Construction of continuous and batch processes.	CO 2	T1: 9.3-9.5, R1:4.3-4.4
12	Importance of power load modeling.	CO 2	T2:9.1, R1:8.1
13	Classification Direct load control.	CO 2	T2:9.8, R1:8.2
14	Development of power flow interruptible load control.	CO 2	T2:9.9.1, R1:9.2
15	Iterative solution bottom up approach.	CO 4	T2:9.8, R1:9.2
16	Scheduling, formulation of load models	CO 4	T2:9.10
17	Iterative optimization and control algorithms.	CO 4	T1:9.10
18	Decoupled and fast case studies.	CO 4	T1:9.11.2
19	Reactive power management in industries.	CO 4	T1:9.12
20	Power flow controls power quality impacts	CO 4	T1:9.4.12, R1:9.2
21	Application of filters.	CO 3	T2:10.3, R1:6.1-6.3
22	Importance of energy saving in industries.	CO 6	T2:10.4, R1:6.4

23	Cooling and heating loads	CO 4	T1:10.5, R1:6.4
24	Load profiling	CO 5	T1:10.6, R1:6.3
25	Computations of modeling	CO 6	T1:10.7, R1:6.3
26	Computations of modeling	CO 6	T1:10.7, R1:6.3
27	Introduction to cool storage.	CO 4	T1:10.5, R1:6.3
28	Types of cool storages.	CO 4	T2:10.13, R1:6.3
29	Control strategies	CO 4	T2:10.13, R1:6.3
30	Optimal operation	CO 4	T1:10.13, R1:6.3
31	Optimal operation	CO 4	T1:10.13, R1:6.3
32	Operating problem formulation	CO 4	T1:10.13
33	Case studies, Captive power UNITs.	CO 5	R1:6.3
34	Operating and control strategies, Power pooling	CO 5	T2:13.7
35	Operating and control strategies, Power pooling	CO 4	T2:13.7
36	Power system operation models, Energy banking	CO 5	T1:13.6, R1:10.5
37	Power system operation models, Energy banking	CO 5	T1:13.6, R1:10.5
38	Selection of schemes	CO 6	T1:13.6
39	Optimal operating strategies	CO 6	T2:13.7
40	Peak load saving.	CO 6	R1:11.5
41	Constraints problem formulation	CO 6	T1:13.7
42	Constraints problem formulation.	CO 6	T1:13.7
43	Case study.	CO 6	T1:13.7
44	Optimal operating strategies.	CO 6	T2:13.7
45	Optimal operating strategies.	CO 6	T2:13.7
46	Optimal operating strategies.	CO 6	T2:13.7
47	Peak load saving	CO 6	T2:13.7
48	Peak load saving	CO 6	T2:13.7
49	Peak load saving	CO 6	T2:13.7
50	Integrated load management for industries	CO 6	T2:13.7
51	Integrated load management for industries	CO 6	T2:13.7
52	Integrated load management	CO 6	T1:200-215
53	Problems	CO 6	T1:486
54	Problems	CO 6	T1:486
55	Problems	CO5	R2:11.8

56	Constraints problem formulation	CO6	T2:9.1 - 9.3
57	Case studies	CO6	T2: 9.4 - 9.5
58	Case studies	CO6	T2: 9.6
59	Problems	CO6	T1:9.7, 9.8
60	Problems	CO6	T1:9.9
DISCUSSION OF QUESTION BANK			
1	MODULE:I-Electric Energy Scenario	CO1	-
2	MODULE:II- Direct Load Control Interruptible Load Control	CO2,CO3	-
3	MODULE:III-Cooling And Heating Loads Load Profiling	CO4	-
4	MODULE:IV-Captive Power Units	CO5	-
5	MODULE:V-Optimal Operating Strategies	CO6	-

Signature of Course Coordinator **HOD,EEE**
Dr. Puppala Rajendhar,Associate Professor

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

COURSE DESCRIPTION

Department	**ELECTRICAL POWER SYSTEMS**				
Course Title	**POWER QUALITY**				
Course Code	BPSC20				
Program	M.Tech				
Semester	II	EPS			
Course Type	Elective				
Regulation	PG21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. G.Ranjith Kumar Gatla, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AEEB20	V	Power Electronics
UG	AEEB22	VI	Power System Analysis

II COURSE OVERVIEW:

This course deals with the basic concepts power quality problems, mitigation techniques used to improve power quality in distribution system. This course is designed to construct study of characterization of voltage sag magnitude and three phase unbalanced voltage sag. This course also concludes with the behavior of power electronics loads, induction motors and synchronous motors.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
POWER QUALITY	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Seminars	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.

50%	To test the objectiveness of the concept
30%	To test the analytical skill of the concept
20%	To test the application skill of the concept

Continuous Internal Assessment (CIA):
For each theory course the CIA shall be conducted by the faculty / teacher handling the course. CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment / AAT shall be considered for computing the final CIA of a student in a given course.

The CIE Tests/Assignment /AAT shall be conducted by the course faculty with due approval from the HOD. Advance notification for the conduction of Assignment/AAT is mandatory and the responsibility lies with the concerned course faculty. CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Technical Seminar and Term Paper

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

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 9^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment:
To improve the writing skills in the course an assignment will be evaluated for 05 marks. One assignment has to submit at the end of the CIE2 for the questions provided by the each course coordinator in that semester. Assignments to be handed in as loose paper collection stapled together at the top left corner. The assignment should be presented as a professional report. It must consist of a cover sheet, content page, and should have an introduction, a body, a conclusion or recommendation, and a reference page.

Alternative Assessment Tool (AAT)
In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). This AAT enables faculty to design own assessment patterns during the CIA. The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. If properly applied, the AAT converts the classroom into an effective learning center.**The AAT may includes, concept videos, course related term paper, technical seminar, term paper, paper presentations conducted by reputed organizations relevant to the course etc.**

VI COURSE OBJECTIVES:

The students will try to learn:

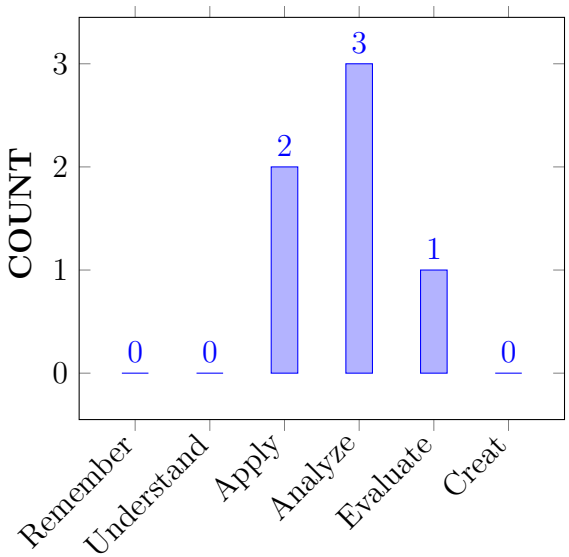
I	Power quality issues in distribution and transmission system.
II	The characterization of voltage unbalance in three phase system.
III	The power quality improvement in different load conditions.

VII COURSE OUTCOMES:

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

CO 1	**Identify** the Power Quality problem by applying the techniques to mitigate them.	Apply
CO 2	**Analyze** the methodology to improve the power quality for sensitive loads by various custom power devices.	Analyze
CO 3	**Analyze** the difference between failure, outage and Interruptions for reliability evaluation to power quality	Analyze
CO 4	**Analyze** e the voltage sag and swell basedpower quality problem in Single phase and three phase system for deenergization of large load	Analyze
CO 5	**Identify** the Power Quality problems in Industry power systems for harmonic distortions in the nonlinear loads.	Apply
CO 6	**Evaluate** power quality monitoring and classification mitigating techniques for the quality of voltage and current produced by a power plant.	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



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VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**An ability** to independently carry out research/investigation and development work to solve practical problems.	3	CIE/SEE/AAT
PO 2	**An ability** to write and present a substantial technical report / document.	2	CIE/SEE/AAT
PO 3	**Student should be able to** demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.	2	CIE/SEE/AAT
PO 6	**Engage** in life-long learning for continuing education in doctoral level studies and professional development.	2	CIE/SEE/AAT

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PROGRAM OUTCOMES					
	1	2	3	4	5	6
CO 1	✓	-	✓	-	-	-
CO 2	✓	✓	-	-	-	-
CO 3	✓	-	-	-	-	-
CO 4	✓	✓	-	-	-	-
CO 5	✓	-	-	-	-	✓
CO 6	✓	-	-	-	-	✓

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	**Apply** the knowledge of mathematics, science, engineering fundamentals for identify the sources of various **power quality problems in distribution system.**	3
	PO 3	research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics for Understand the factors that causes the harmonics and their effect	2
CO 2	PO 1	Explain the operating principles of renewable energy sources using science and engineering fundamentals	3
	PO 2	Analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics for Understand the factors that causes the harmonics and their effect on the power system	2

CO 3	PO 1	Recall power flow in transmission lines for stable operation of power systems for using principles of mathematics, science and engineering fundamentals.	3
CO 4	PO 1	Demonstrate the Static VAR Compensator, its configuration using basics engineering sciences.	3
	PO 2	Analyze the encompassing capabilities of voltage regulation, series compensation, and phase shifting in electrical components..	2
CO 5	PO 1	Recall the 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.	3
	PO 6	Analyze the Static Synchronous Compensator (STATCOM) and Thyristor Controlled Series Capacitor (TCSC) in life-long learning	2
CO 6	PO 1	Recall the importance of controllers according to the necessities	3
	PO 6	Mode l the SSSC involves power flow Studies which include the calculation of bulbar voltage, branch loadings, and real, reactive transmission losses in life-long learning	2

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

COURSE OUTCOMES	**Program Outcomes/ No. of Key Competencies Matched**					
	1	2	3	4	5	6
CO 1	3	-	2	-	-	-
CO 2	3	2	-	-	-	-
CO 3	3	-	-	-	-	-
CO 4	3	2	-	-	-	-
CO 5	3	-	-	-	-	2
CO 6	3	-	-	-	-	2

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

COURSE OUTCOMES	PROGRAM OUTCOMES					
	1	2	3	4	5	6
CO 1	100	0.0		57.2	0.0	0.0
CO 2	100	40	0.0	0.0	0.0	0.0
CO 3	100	0.0	0.0	0.0	0.0	0.0
CO 4	100	40	0.0	0.0	0.0	0.0
CO 5	100	0.0	0.0	0.0	0.0	100
CO 6	100	0.0	0.0	0.0	0.0	100

XIII 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≤ C≤ 5% – No correlation
1-5 <C≤ 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES					
	1	2	3	4	5	6
CO 1	3	-	2	-	-	-
CO 2	3	2	-	-	-	-
CO 3	3	-	-	-	-	-
CO 4	3	2	-	-	-	-
CO 5	3	-	-	-	-	2
CO 6	3	-	-	-	-	2
TOTAL	18	4	2	-	-	4
AVERAGE	3.0	2	2	-	-	2

XIV 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	-	-	-	-	

XV ASSESSMENT METHODOLOGY INDIRECT:

✓	**End Semester OBE Feed Back**

XVI SYLLABUS:

MODULE I	**INTRODUCTION**
	Introduction of the power quality (PQ): Problem, terms used in PQ voltage, sag, swell, surges, harmonics, over voltages, spikes, voltage fluctuations, transients, interruption, overview of power quality phenomenon, remedies to improve power quality, power quality monitoring.
MODULE II	**LONG AND SHORT INTERRUPTIONS**
	Interruptions: Definition, difference between failures, outage, interruptions, causes of long interruptions , origin of interruptions, limits for the interruption frequency, limits for the interruption duration, costs of interruption, overview of reliability evaluation to power quality, comparison of observations and reliability evaluation; Short Interruptions: Definition, origin of short interruptions, basic principle, fuse saving, voltage magnitude events due to re-closing, voltage during the interruption, monitoring of short interruptions, difference between medium and low voltage systems, multiple events, single phase tripping, voltage and current during fault period, voltage and current at post fault period, stochastic prediction of short interruptions
MODULE III	**SINGLE AND THREE-PHASE VOLTAGE SAG CHARACTERIZATION**
	Voltage sag: Definition, causes of voltage sag, voltage sag magnitude, and monitoring, theoretical calculation of voltage sag magnitude, voltage sag calculation in non-radial systems, meshed systems, and voltage sag duration. Three phase faults: Phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags, load influence on voltage sags.
MODULE IV	**POWER QUALITY CONSIDERATIONS IN INDUSTRIAL POWER**
	Voltage sag; Equipment behavior of power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation, mitigation of ac drives, adjustable speed dc drives and its operation, mitigation methods of dc drives
MODULE V	**MITIGATION OF INTERRUPTIONS AND VOLTAGE SAG**
	Overview of mitigation methods: From fault to trip, reducing the number of faults, reducing the fault clearing time changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods; System equipment interface: Voltage source converter, series voltage controller, shunt controller, combined shunt and series controller.

TEXTBOOKS

1. Math H J Bollen,"Understanding Power Quality Problems", IEEE Press, 1st Edition, 2007.

2. Sastry Vedam Mulukutla S Sarma, "Power Quality VAR Compensation in Power Systems", R,CRC Press, 1st Edition, 2004.

REFERENCE BOOKS:

1. G T Heydt, "Electric Power Quality", (West Lafayette, IN, Stars in a circle Publications, 1 st Edition, 1994.

2. A Ghosh, G Ledwich, "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic, 1 st Edition, 2002.

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 T1: 4.1
OBE DISCUSSION			
1	Course Objectives, Course Outcomes, CO-PO Mapping, Blooms Taxonomy, CO Articulation Matrix		
CONTENT DELIVERY (THEORY)			
1	Introduction of the power quality (PQ)	CO1	T1: 1.1,
2	Problem, terms used in PQ voltage, sag, swell, surges	CO1	T1: 1.1,
3	terms used in PQ harmonics, over voltages	CO1	T1: 1.1,
4	transients, interruption,	CO1	T1: 1.1,
5	remedies to improve power quality	CO1	T1: 1.2
6	power quality monitoring	CO1	T1: 1.2
7	spikes, voltage fluctuations	CO1	T1: 1.3
8	overview of power quality phenomenon	CO1	T1: 3.6
9	Interruptions: Definition, difference between failures	CO2	T1: 1.1
10	outage, interruptions, causes of long interruptions	CO2	T1: 1.1,
11	origin of interruptions, limits for the interruption frequency	CO2	T1: 4.2,4.3
12	limits for the interruption duration, costs of interruption	CO2	T1: 4.2,4.3 T2:26.10
13	overview of reliability evaluation to power quality,	CO2	T1: 4.4
14	comparison of observations and reliability evaluation	CO2	R2: 4.7
15	Short Interruptions: Definition, origin of short interruptions,	CO2	T1: 4.9
16	basic principle, fuse saving	CO2	T1: 4.9
17	voltage magnitude events due to re-closing	CO2	T1: 5.1,5.4
18	voltage during the interruption	CO2	T1: 5
19	difference between medium and low voltage systems,	CO2	T1: 5.1
20	multiple events, single phase tripping	CO2	T1: 5.1
21	voltage and current during fault period	CO2	T1: 5.1
22	stochastic prediction of short interruptions	CO2	T1: 6.1,6.4,6.5
23	voltage and current at post fault period	CO2	T1: 6.1,6.4,6.5
24	monitoring of short interruptions	CO2	T1: 6.1
25	Voltage sag: Definition, causes of voltage sag	CO3	T1: 6.1
26	voltage sag magnitude, and monitoring	CO3	T1: 6.1
27	theoretical calculation of voltage sag magnitude	CO3	T1: 6.1
28	voltage sag calculation in non-radial systems	CO3	T1: 6.13
29	meshed systems, and voltage sag duration	CO3	R1: 6.14
30	Three phase faults: Phase angle jumps	CO4	T1 : 9
31	magnitude jumps for three phase unbalanced sags	CO4	T1: 9.5

32	magnitude jumps for three phase unbalanced sags	CO4	T1: 9.5
33	phase angle jumps for three phase unbalanced sags	CO4	T1: 9.5
34	load influence on voltage sags.	CO4	R2: 9.6
35	Voltage sag; Equipment behavior of power electronic loads	CO5	R3: 1.5,
36	Voltage sag; Equipment behavior of power electronic loads	CO5	R3: 1.5,
37	induction motors, synchronous motors	CO5	1.9
38	computers, consumer electronics	CO5	T1: 9.1
39	mitigation of ac drives	CO5	R3: 2.6
40	adjustable speed dc drives and its operation	CO5	T1: 9.1
41	adjustable speed dc drives and its operation	CO5	T1: 9.1
42	adjustable speed AC drives and its operation	CO5	R3: 4.3,
43	mitigation methods of dc drives.	CO5	4.8
44	mitigation methods of dc drives.	CO5	4.8
45	Overview of mitigation methods: From fault to trip	CO5	R1: 9.9 R3:5.8, 5.11
46	Overview of mitigation methods: From fault to trip	CO5	R1: 9.9 R3:5.8, 5.11
47	Overview of mitigation methods: From fault to trip	CO5	R1: 9.9 R3:5.8, 5.11
48	reducing the number of faults	CO5	T1 : 9.1
49	reducing the number of faults	CO5	T1 : 9.1
50	reducing the number of faults	CO5	T1 : 9.1
51	reducing the fault clearing time changing the power system	CO5	T1 : 9.1
52	installing mitigation equipment	CO6	T1 : 9.1
53	improving equipment immunity	CO6	T1 : 9.1
54	different events and mitigation methods	CO6	T1 : 9.1
55	different events and mitigation methods	CO6	T1 : 9.1
56	System equipment interface: Voltage source converter	CO6	T1 : 9.1
57	System equipment interface: Voltage source converter	CO6	T1 : 9.1
58	series voltage controller	CO6	T1 : 9.1
59	shunt controller	CO6	T1 : 9.1
60	combined shunt and series controller	CO6	T1 : 9.1

DISCUSSION OF QUESTION BANK			
1	Problem, terms used in PQ voltage, sag, swell, surges	CO1	R4:2.1
2	Origin of interruptions	CO2	T4:7.3
3	Voltage sag, Three phase faults	CO3, CO4	R4:5.1
4	Equipment behavior of power electronic loads	CO4	T1:7.5
5	Overview of mitigation methods	CO5	T1: 4.1

Signature of Course Coordinator **HOD,EEE**
Dr. G.Ranjith Kumar Gatla, Associate Professor

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

ELECTRICAL AND ELECTRONICS ENGINEERING
COURSE DESCRIPTION

Course Title	ARTIFICIAL INTELLIGENCE LABORATORY				
Course Code	BPSC23				
Program	M.Tech				
Semester	II	EEE			
Course Type	Laboratory				
Regulation	IARE - PG21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	4	2
Course Coordinator	Dr. A Naresh Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEC12	VI	Power System Analysis

II COURSE OVERVIEW:

The objective of artificial intelligence laboratory is to analyze electrical power system in load flow analysis, asses the different state estimation techniques, analyze the power system under fault conditions and evaluate the economic dispatch of coordinated thermal unit. Artificial intelligence including artificial neural networks, fuzzy logic and genetic algorithms. Provide the mathematical background for carrying out the optimization associated with neural network learning.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Artificial Intelligence Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

x	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	**Laboratory**		**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:

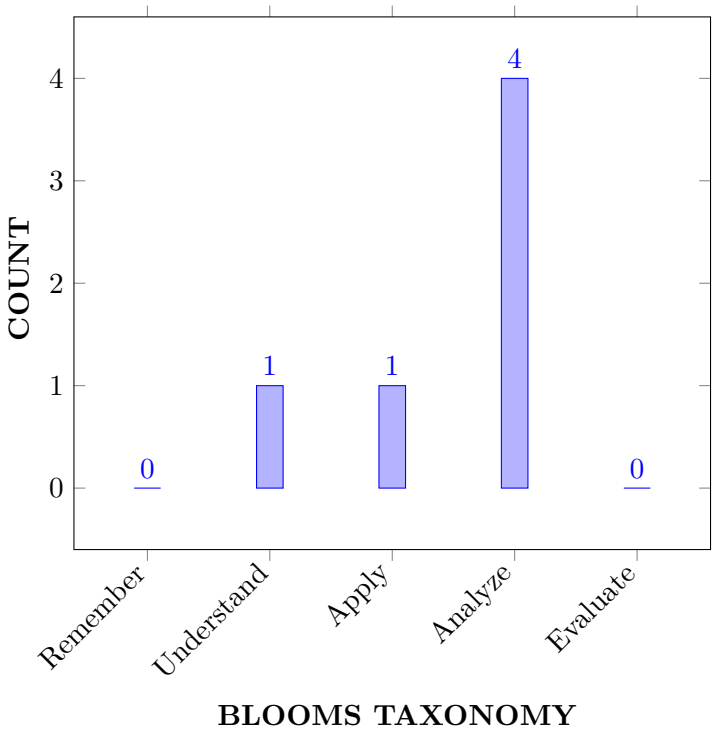
I	Explain the different state estimation techniques
II	Analyze and pick the best artificial intelligence technique for a given Power System problem.
III	Evaluate the economic dispatch of coordinated thermal unit
IV	Identify and use modern tools like fuzzy logic, artificial neural networks and ANFIS for power system problems

VII COURSE OUTCOMES:

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

CO 1	**Develop** a neural network based model for Load flow analysis. .	Analyze
CO 2	**Analyze** the state estimations using neural network.	Analyze
CO 3	**Analyze** contingency technique to predict the effect of outages like failures of equipment , transmission line u sing ANN	Analyze
CO 4	**Apply** the power system security using neural network.	Apply
CO 5	**Determine** automatic Generation Control for single area system and two area systems using Fuzzy Logic Method.	Understand
CO 6	**Analyze** the transient and small signal stability analysis of Single-Machine-Infinite Bus (SMIB) system using Fuzzy Logic	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	3	Lab Exercises
PO 2	An ability to write and present a substantial technical report / document.	3	Lab Exercises
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.	3	Lab Exercises

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

XI ASSESSMENT METHODOLOGY DIRECT:

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

XII ASSESSMENT METHODOLOGY INDIRECT:

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

XIII SYLLABUS:

WEEK I	**LOAD FLOW ANALYSIS**
	Load flow analysis using neural network
WEEK II	**STATE ESTIMATIONS**
	State estimations using neural network.
WEEK III	**CONTINGENCY ANALYSIS**
	Power system security using neural network.
WEEK IV	**POWER SYSTEM SECURITY**
	Contingency analysis using neural network
WEEK V	**AGC - SINGLE AREA SYSTEM / TWO AREA SYSTEM**
	Fuzzy logic based AGC for single area system and two area systems.
WEEK VI	**SMALL SIGNAL STABILITY ANALYSIS**
	Fuzzy logic based small signal stability analysis.
WEEK VII	**ECONOMIC DISPATCH THERMAL UNITS**
	Economic dispatch of thermal UNITs using conventional and GA logic.
WEEK VIII	**ECONOMIC DISPATCH THERMAL UNITS**
	Economic dispatch of thermal UNITs using conventional and ANN logic.
WEEK IX	**ECONOMIC DISPATCH THERMAL UNITS**
	Economic dispatch of thermal UNITs using conventional and Fuzzy logic.
WEEK X	**ECONOMIC DISPATCH OF THERMAL PLANTS**
	Economic dispatch of thermal plants using conventional and ANN algorithms.
WEEK XI	**ECONOMIC DISPATCH OF THERMAL PLANTS**
	Economic dispatch of thermal plants using conventional and GA algorithms.
WEEK XII	**ECONOMIC DISPATCH OF THERMAL PLANTS**
	Economic dispatch of thermal plants using conventional and Fuzzy logic.

TEXTBOOKS

1. Samuel Greengard, K B Kanchandhani, “The Artificial Intelligence”, Tata Mc Graw Hill Publishing Company, 2nd Edition, 1998.
2. Cuno Pfister, “Getting started with Artificial Intelligence”, Khanna Publishers, 5th Edition, 2012.

REFERENCE BOOKS:

1. Vedam Subramanyam, “Learning Artificial Intelligence”, New Age International Limited, 2nd Edition, 2006.
2. Klaus Schwab, “The Fourth Artificial IntelligenceRevolution”, New Age International Limited, 2nd Edition, 2008.

XIV 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	Load flow analysis using neural network	CO 1	T1:3.1
2	State estimations using neural network.	CO 2	T1:3.11
3	Power system security using neural network.	CO 3	T1:4.8
4	Contingency analysis using neural network	CO 2	T1:4.8
5	Fuzzy logic based AGC for single area system and two area systems.	CO 3	T1.5.5
6	Fuzzy logic based small signal stability analysis.	CO 4	T1:5.6
7	Economic dispatch of thermal UNITs using conventional and GA logic.	CO 4	T1:8.3
8	Economic dispatch of thermal UNITs using conventional and ANN logic.	CO 5	T1:8.3
9	Economic dispatch of thermal UNITs using conventional and Fuzzy logic.	CO 3	T1:9.2
10	Economic dispatch of thermal plants using conventional and ANN algorithms.	CO 5	T1:9.3
11	Economic dispatch of thermal plants using conventional and GA algorithms.	CO 3	T1:10.6
12	Economic dispatch of thermal plants using conventional and Fuzzy logic.	CO 6	T1:10.7

XV EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Determine the economic dispatch of thermal plants
2	Determine the state estimations .
3	Determine the single area system and two area systems
4	Determine the mamdani fuzzy inference system.
5	Determine the Back propegation algorithm

Signature of Course Coordinator **HOD, EEE**
Dr. A Naresh Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
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Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRONICS ENGINEERING
COURSE DESCRIPTION

Course Title	**POWER SYSTEMS LABORATORY**				
Course Code	BPSC24				
Program	M.Tech				
Semester	II	EEE			
Course Type	Core				
Regulation	IARE - PG 21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	4	2
Course Coordinator	Mr. P. Shivakumar, Assistant Professor				

I COURSE OVERVIEW:

The objective of the course is to provide an overview of basic protection methods such as earthing, milli volt drop test, soil resistivity and determination of breakdown voltage of air using horn gap apparatus. It provides in depth knowledge on working of microprocessor based over current relay and electromechanical over current relay. In addition to this, merz price protection of single phase transformer is studied. It provides in depth knowledge on working of various types of relays in protection of alternator.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECC05	III	Electronic Devices and Circuits Laboratory

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Power System Computational 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. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	Determine the earth resistance and electrical integrity of connections using crank type earth tester and milli volt drop test.
II	Understand the concept of Merz price protection of single phase transformer.
III	Examine the performance of alternator under various fault conditions using suitable relays.

VII COURSE OUTCOMES:

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

CO 1	**Determine** earth resistance by using crank type earth tester.	Understand
CO 2	**Develop** the programming for load flow algorithms.	Apply
CO 3	**Analyze** the characteristics of fast decoupled loaf flow methods for developing algorithm.	Analyze
CO 4	**Categorize** the transient and short circuit analysis for analysing the performance of the system.	Apply
CO 5	**Categorize** the transient and short circuit analysis for analysing the performance of the system.	Analyze
CO 6	**Analyze** the various iterative methods applicable for state estimation of the power system.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL

VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	3	Lab Exercises
PO 2	An ability to write and present a substantial technical report / document..	3	Lab Exercises
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.	3	Lab Exercises
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	3	Lab Exercises
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment..	2	Lab Exercises
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X 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
CO 1	3	3	-	-	2	-
CO 2	-	3	3	-	-	2

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

XI ASSESSMENT METHODOLOGY DIRECT:

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

XII ASSESSMENT METHODOLOGY INDIRECT:

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

XIII SYLLABUS:

WEEK I	**EARTH TESTER**
	Determination of earth resistance by using crank type earth tester.
WEEK II	**MILLI VOLT DROP TEST**
	Measurement of contact resistances of different combinations of test objects.
WEEK III	**SOIL RESISTIVITY**
	Measurement of soil resistivity as a function of salinity and time.
WEEK IV	**MICROPROCESSOR BASED OVER CURRENT RELAY**
	Determination of performance characteristics of microprocessor based over current relay.
WEEK V	**ELECTROMECHANICAL OVER CURRENT RELAY**
	Determination of performance characteristics of electromechanical over current relay.
WEEK VI	**BREAKDOWN STRENGTH OF AIR BY HORN GAP**
	Determination of breakdown voltage of air using horn gap apparatus at atmospheric conditions.
WEEK VII	**POWER ANGLE CHARACTERISTICS OF SYNCHRONOUS MACHINE**
	Study the power angle characteristics of synchronous machine by synchronizing to the grid.
WEEK VIII	**MERZ PRICE PROTECTION IN SINGLE PHASE TRANSFORMER**
	Study the Merz price protection of single phase transformer and determine the characteristics of percentage biased relay.
WEEK IX	**DIFFRENTIAL PROTECTION SCHEME IN SYNCHRONOUS GENERATOR**
	Study of differential protection in three phase ac generator.

WEEK X	**OVER CURRENT AND TEMPARATURE PROTECTION IN ALTERNATOR**
	Study the performance of over current relay and temperature relay to protect alternator.
WEEK XI	**NEGATIVE SEQUENCE PROTECTION IN ALTERNATOR**
	Study the numerical type negative sequence protection in a given alternator.
WEEK XII	**OVER VOLTAGE AND UNDER VOLTAGE PROTECTION**
	Examine the alternator during over voltage and under voltage by using respective relays.
WEEK XIII	**OVER FREQUENCY AND UNDER FREQUENCY PROTECTION**
	Study the generator protection during over and under frequency cases with suitable relays.
WEEK XIV	**PERFORMANCE OF ALTERNATOR AGAINST INTERNAL FAULTS**
	Study the performance of synchronous machine and its protection scheme during internal faults.

TEXTBOOKS

1. 1. DP Kothari, B S Umre, "Lab manual for Electrical Machines", IK International Publishing House Pvt. Ltd, 1st Edition, 1996.

REFERENCE BOOKS:

1. MariesaLCrow, "Computational Methods for Electric Power Systems (Electric Power Engineering Series)", CRC Press Publishers, 1st Edition, 1992.

XIV 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	Determine earth resistance by using crank type earth tester.	CO 1	T1:3.1
2	Explain the concept of electrical integrity of connections and contacts in a circuit breaker using milli volt drop test.	CO 2	T1:3.11
3	Understand the concept of soil resistivity as function of salinity and time.	CO 3	T1:4.8
4	Understand the working principle of microprocessor based over current relay.	CO 2	T1:4.8
5	Understand the working principle of electromechanical over current relay.	CO 3	T1.5.5
6	Determine of breakdown voltage of air using horn gap apparatus.	CO 4	T1:5.6
7	Estimate the power angle characteristics of synchronous machine.	CO 4	T1:8.3
8	Analyze internal fault protection of single phase transformer using Merz price protection.	CO 5	T1:8.3
9	Understand the concept of differential protection in three phase ac generator.	CO 3	T1:9.2

10	Examine the performance of over current relay, temperature relay and numerical type negative sequence protection scheme for alternator.	CO 5	T1:9.3
11	Examine the alternator during over voltage, under voltage, over and under frequency by using respective relays.	CO 3	T1:10.6
12	Examine the performance of alternator during internal faults.	CO 6	T1:10.7
13	Understand the generator protection during over and under frequency cases with suitable relays.	CO 3	T1:10.6
14	Examine the performance of synchronous machine and its protection scheme during internal faults.	CO 6	T1:10.7

XV EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design analysis of Numerical Relays for protection in power system.
2	Determine cuases of internal and externavfault protection of transformer
3	Design analysis of generator protection during over and under frequency cases.
4	Design analysis of over voltage prortection schemes in power systems
5	Design analysis of microprocessor based relays for protection in power system .

Signature of Course Coordinator **HOD,EEE**
Mr. P Shiva Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
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COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**RESEARCH METHODOLOGY AND IPR**				
Course Code	BHSC11				
Program	M.Tech				
Semester	III	EEE			
Course Type	Core				
Regulation	IARE PG21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	-	2	-	-
Course Coordinator	Dr. Ranjith Kumar Gatla, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
M.Tech	-	-	-

II COURSE OVERVIEW:

This course provides the basic concepts on research methodology and intellectual property rights. This course emphasis on sampling techniques, data collection, writing Reports, Projects, Dissertations, thesis and articles for publication in academic journals, avail the intellectual property rights of the inventors or owners for their assets like patents on innovative design, copy rights on literary and artistic works, trademark on goods & services and geographical indications on products famous for specific geographical areas.This course makes use of the potential future economic benefits to the intellectual property owner or authorized user.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Research Methodology and IPR	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). **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 three sub divisions in a question.

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

50 %	To test the objectiveness of the concept
30 %	To test the analytical skill of the concept
20 %	To test the application skill of the concept

Continuous Internal Assessment (CIA):

For each theory course the CIA shall be conducted by the faculty / teacher handling the course. CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment / AAT shall be considered for computing the final CIA of a student in a given course.

The CIE Tests/Assignment /AAT shall be conducted by the course faculty with due approval from the HOD. Advance notification for the conduction of Assignment/AAT is mandatory and the responsibility lies with the concerned course faculty. CIA is conducted for a total of 30 marks (Table 1).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Assignment	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 25 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/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:

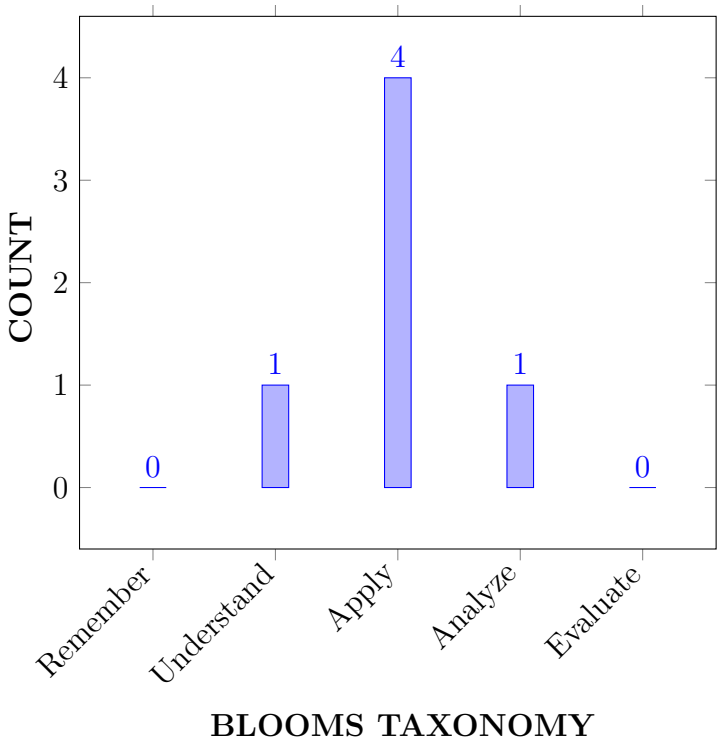
I	The knowledge on sources of research problem, data collection, analysis, and interpretation.
II	The importance of effective technical writing and analysis plagiarism.
III	The new developments in the law of intellectual property rights in order to bring progressive changes towards a free market society.

VII COURSE OUTCOMES:

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

CO 1	**Interpret** the technique of determining a research problem for a crucial part of the research study	Understand
CO 2	**Examine** the way of methods for avoiding plagiarism in research	Analyze
CO 3	**Apply** the feasibility and practicality of research methodology for a proposed project	Apply
CO 4	**Make use of** the legal procedure and document for claiming patent of invention.	Apply
CO 5	**Identify** different types of intellectual properties, the right of ownership, scope of protection to create and extract value from IP	Apply
CO 6	**Defend** Defend the intellectual property rights throughout the world with the involvement of World Intellectual Property Organization	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	2	CIE/AAT/SEE
PO 2	An ability to write and present a substantial technical report / document.	3	CIE/AAT/SEE
PO 3	Student should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.	2	CIE/AAT/SEE
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	2	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	-	-	-	✓
CO 2	✓	-	-	-	-	✓
CO 3	✓	✓	✓		-	-
CO 4	✓	✓	-		-	-
CO 5	✓	-	-	-		✓
CO 6	-	✓	-	-	-	-

XI COURSE ARTICULATION MATRIX (CO-PO 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.

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	-	-	-	2
CO 2	2	-	-	-	-	1
CO 3	2	3	2	-	-	-
CO 4	3	2	-	-	-	-
CO 5	2	-	-	-	-	2
CO 6	-	3	-	-	-	-
TOTAL	12	11	2	-	-	5
AVERAGE	2.4	2.75	2	-	-	1.7

XII ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminar and term paper	-
Laboratory Practices	-	Student Viva	-	Mini Project	-

XIII ASSESSMENT METHODOLOGY-INDIRECT:

✓	**End Semester OBE Feed Back**

XIV SYLLABUS:

MODULE I	**INTRODUCTION**
	Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations
MODULE II	**RESEARCH ETHICS**
	Effective literature studies approaches, analysis Plagiarism, Research ethics.
MODULE III	**RESEARCH PROPOSAL**
	Effective technical writing, how to write report, Paper Developing a Research Proposal. Format of research proposal, a presentation and assessment by a review committee
MODULE IV	**PATENTING**
	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT

MODULE V	**PATENT RIGHTS**
	Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs

TEXTBOOKS

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science and engineering students".
2. C R Kothari, "Research Methodology: Methods and techniques", New age international limited publishers, 1990 .
3. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"

REFERENCE BOOKS:

1. Halbert, "Resisting Intellectual Property", Taylor and Francis Ltd , 2007.
2. Mayall , "Industrial Design", McGraw Hill, 1992.
3. Niebel , "Product Design", McGraw Hill, 1974.

WEB REFERENCES:

1. Robert P. Merges, Peter S. Menell, Mark A. Lemley Age", 2016 , " Intellectual Property in New Technological Age", 2016
2. T. Ramappa, "Intellectual Property Rights Under WTO" S. Chand 2008
3. Peter-Tobias stoll, Jan busche, Katrianarend- WTO- Trade –related aspects of IPR- Library of Congress

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
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, Definition, types of research	CO 1	T1:2.1
2	Meaning of research problem	CO 1	T1:2.1
3	Sources of research problem	CO 1	T1:2.3
4	Criteria characteristics of good research problem	CO 1	T1:2.3.1
5	Research process	CO 1	T1:7.2
6	Research design	CO 1	T1:7.3

7	Errors in selecting a research problem	CO 1	T1:7.4
8	Scope and objectives of research problem	CO 1	T1:2.3
9	Approaches of investigation of solutions for research problem	CO 1	T1:7.4
10	Data collection	CO 1	T1:8.1
11	Analysis and interpretation of data	CO 1	T1:8.1.1
12	Necessary instrumentation's	CO 1	T1:8.1.1
13	Effective literature studies approaches	CO 2	T1:8.2
14	Literature	CO 2	T1:8.2
15	Literature review	CO 2	T1:8.2
16	Literature review techniques	CO 2	T1:8.2
17	Literature studies	CO 2	T1:8.2
18	Introduction to ethics, Importance of ethics	CO 2	T1:8.2
19	Ethical issues in conducting research	CO 2	T1:8.3
20	Principles of research ethics	CO 2	T1:8.4
21	Analysis	CO 2	T1:8.5
22	Plagiarism- types of plagiarism	CO 2	T1:8.6
23	Tips to avoid plagiarism	CO 2	T1:9.1
24	Other ethical issues	CO 2	T1:9.2, 9.3
25	Interpretation, Interpretation Techniques and precautions	CO 2	T2:9.3.4
26	Writing of report and steps involved	CO 3	T2:7.1
27	Layout of research report	CO 3	T2:7.2
28	Types of reports	CO 3	T2:7.3
29	Paper developing a research proposal	CO 3	T2:7.4
30	Format of research proposal	CO 4	T2:8.3
31	Presentation of report	CO 4	T2:8.4
32	Summary of findings	CO 4	T3:8.5
33	Assessment by review committee	CO 4	T3:8.6
34	Technical appendixes	CO 4	T3:8.6
35	Logical analysis of the subject matter	CO 4	T3:8.6
36	Statement of findings and recommendations	CO 4	T3:8.6
37	Introduction, Nature of Intellectual Property	CO 5	T3:10.1-10.6
38	Types of intellectual Property rights	CO 5	T3:10.1-10.6
39	Patents	CO 5	T3:11.10
40	Designs	CO 5	T3:11.10
41	Trademarks and copyrights: Definition, classification of trademarks	CO 5	T3:11.10
42	Process of Patenting and Development	CO 5	T3:11.14
43	Technical research, innovation, patenting	CO 5	T3:11.15
44	Developments in patenting	CO 5	T3:11.17
45	Patent Trademark Organization	CO 5	T3:11.17
46	International Organization, Agencies and Treaties	CO 5	T3:11.17

47	International scenario, international cooperation on Intellectual property	CO 5	T3:11.19
48	Procedure for grant of patents	CO 5	T3:11.21
49	procedure of copyright	CO 5	T1:8.1-8.3; R2: 7.4-7.5
50	Patenting under PCT, Provisional patent application	CO 5	T1-8.1-8.1.7
51	Patent protection for the invention	CO 5	T1-8.1-8.1.7
52	Patent Rights	CO 6	T3:12.1
53	Scope of Patent Rights	CO 6	T3:12.1
54	Licensing and transfer of technology	CO 6	T3:12.1
55	Patent information and databases	CO 6	T3:12.4
56	Geographical Indications	CO 6	T3:12.4
57	New Developments in IPR: Administration of Patent System	CO 6	T3:12.7
58	New developments in IPR, IPR of Biological Systems and Computer Software etc	CO 6	T3:12.10
59	Traditional knowledge Case Studies	CO 6	T3:12.13
60	IPR and IITs.	CO 6	T3:12.15
DISCUSSION OF QUESTION BANK			
61	Module – I: Research problem	CO 1	T1:2.1-2.3
62	Module – II: Research ethics	CO 2	T1:8.2
63	Module – III: Research proposal	CO 3, CO 4	T3:8.3; R2: 7.4-7.5
64	Module – IV: Patenting	CO 5	T3:10.1-10.6
65	Module – V: Patent rights	CO 6	T3:12.1-12.15

Signature of Course Coordinator **HOD, EEE**
Dr. Ranjith Kumar Gatla, Associate Professor

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

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**SCADA SYSTEM AND APPLICATIONS**				
Course Code	BPSC26				
Program	M.Tech				
Semester	III				
Course Type	Core				
Regulation	PG21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. G.Viswanath , Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEC22	VI	Power System Analysis
B.Tech	AEEC03	VI	Electric Drives and Static Control

II COURSE OVERVIEW:

This course will provide the mathematical background of digital protection and understanding the importance of Digital Relays. It will also develop various protection algorithms. It will also cover the application of digital protection.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Digital Protection of Power System	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.

50%	To test the objectiveness of the concept
30%	To test the analytical skill of the concept
20%	To test the application skill of the concept

Continuous Internal Assessment (CIA):
For each theory course the CIA shall be conducted by the faculty / teacher handling the course. CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment / AAT shall be considered for computing the final CIA of a student in a given course.

The CIE Tests/Assignment /AAT shall be conducted by the course faculty with due approval from the HOD. Advance notification for the conduction of Assignment/AAT is mandatory and the responsibility lies with the concerned course faculty. CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Technical Seminar and Term Paper

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Assignment	AAT	
CIA Marks	20	5	5	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 9^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment:
To improve the writing skills in the course an assignment will be evaluated for 05 marks. One assignment has to submit at the end of the CIE2 for the questions provided by the each course coordinator in that semester. Assignments to be handed in as loose paper collection stapled together at the top left corner. The assignment should be presented as a professional report. It must consist of a cover sheet, content page, and should have an introduction, a body, a conclusion or recommendation, and a reference page.

Alternative Assessment Tool (AAT)
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VI COURSE OBJECTIVES:

The students will try to learn:

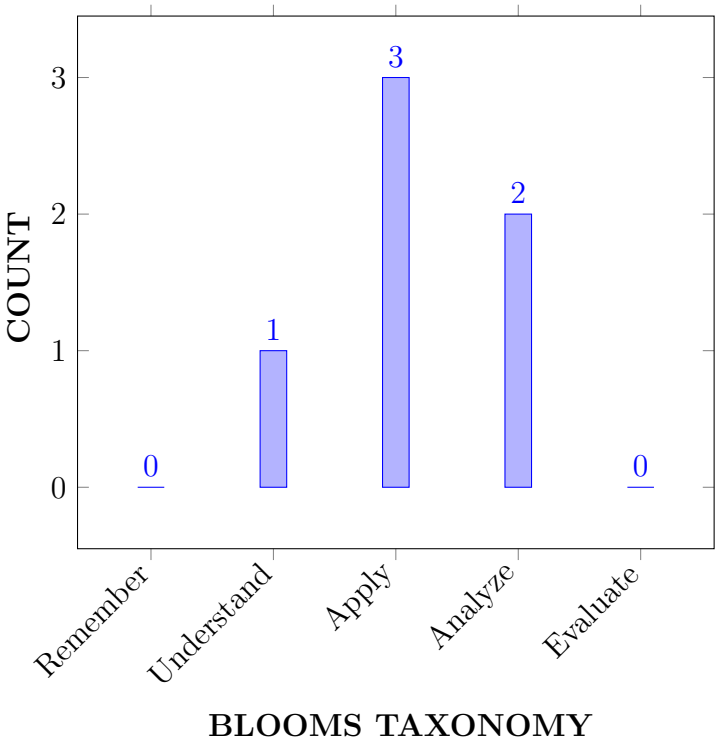
I	The need of numerical relays and their importance in digital protection of the power system.
II	The mathematical approach towards designing algorithms for the protection of power system.
III	The methods of protection employed for the transformers and transmission lines.

VII COURSE OUTCOMES:

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

CO 1	**Illustrate** the significance of protection systems and elements involved in protection of the power system.	Understand
CO 2	**Develop** the structures, mathematical models and formulae of digital relays for mathematical analysis of the system.	Apply
CO 3	**Identify** the basic components of digital relay and signal conditioning subsystems for implementation of digital protection.	Apply
CO 4	**Develop** the mathematical models for analysis of the relying algorithms to address the various types of faults in the power system.	Apply
CO 5	**Categorize** the digital relying algorithms to minimize the transient deviations and steady state error to zero	Analyze
CO 6	**Analyze** the various algorithms applicable for protection of Transformers and transmission lines.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	2	CIE/AAT
PO 2	An ability to write and present a substantial technical report / document.	3	AAT
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.	2	AAT
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	2	AAT
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.	1	AAT
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	1	AAT

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	-	-	-	-
CO 2	-	✓	✓	✓	-	-
CO 3	-	✓	-	✓	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 4	✓	✓	-	✓	-	-
CO 5	-	✓	-	-	✓	-
CO 6	-	✓	-	-	✓	✓

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 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
CO 2	PO 2	**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 3	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 4	**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
CO 3	PO 2	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 4	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**.	
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 switched mode regulators	6
CO 5	PO 2	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 5	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
CO 6	PO 2	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 5	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 6	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

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

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	-	-	-	-
CO 2	✓	✓	✓	-	-	-
CO 3	✓	✓	-	-	-	-
CO 4	✓	✓	-	✓	-	-
CO 5	✓	✓	-	✓	-	-
CO 6	✓	✓	-	✓	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	-	-	-	-
CO 2	✓	✓	✓	-	-	-
CO 3	✓	✓	-	-	-	-
CO 4	✓	✓	-	✓	-	-
CO 5	✓	✓	-	✓	-	-
CO 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					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	2	-	-	-	-
CO 2	3	2	2	-	-	-
CO 3	3	2	-	-	-	-
CO 4	3	2	-	1	-	-
CO 5	3	2	-	1	-	-
CO 6	3	2	-	1	-	-
TOTAL	18	12	2	3	-	1
AVERAGE	3	2	1	1	-	1

XV 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	-	-	-	-	

XVI ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVII SYLLABUS:

MODULE I	**INTRODUCTION TO SCAD AND PLC**
	Data acquisition system, evaluation of SCADA, communication technologies, monitoring and supervisory functions; PLC: Block diagram, programming languages, ladder diagram, functional block diagram, applications, interfacing of PLC with SCADA
MODULE II	**SCADA SYSTEM COMPONENTS**
	Industries SCADA system components: Schemes, remote terminal unit (RTU), intelligent electronic devices (IED), communication network, SCADA server, SCADA / HMI systems
MODULE III	**SCADA ARCHITECTURE AND COMMUNICATION**
	SCADA architecture: Types, advantages and disadvantages of each system, single unified standard architecture-IEC 61850. SCADA Communication: Various industrial communication technologies, wired and wireless methods, fiber optics, open standard communication protocols.
MODULE IV	**OPERATION AND CONTROL**
	SCADA Operation and Control: Operation and control of interconnected power system, automatic substation control, SCADA configuration, energy management system, system operating states, system security, state estimation unit. .
MODULE V	**:SCADA APPLICATIONS**
	SCADA Applications: Utility applications, transmission and distribution sector operations, monitoring, analysis and improvement, industries, oil, gas and water, case studies, implementation, simulation exercises

TEXTBOOKS

1. Stuart A. Boyer: "SCADA-Supervisory Control and Data Acquisition", Instrument Society of America Publications, USA,2004.
2. AT Johns and S K Salman, "Digital Protection of Power Systems", IEEE Press, 1st Edition, 1999

REFERENCE BOOKS:

1. William T. Shaw, "Cybersecurity for SCADA systems", Penn Well Books,2006

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 Description on Outcome Based Education (OBE)		
CONTENT DELIVERY (THEORY)			
1	Data acquisition system, evaluation of SCADA	CO1	T2: 1.1,1.2
2	PLC Bloc Diagrams, Interfacing of PLCs with SCADA	CO1	T1: 1.3,1.4
3	ladder diagram, functional block diagram, applications	CO1	T2: 1.5.1.6
4	Interfacing of PLC with SCADA	CO1	T2: 3.1
5	Industries SCADA system components,	CO1	T2: 3.2
6	Schemes, remote terminal unit (RTU)	CO1	T2:2.1
7	Intelligent electronic devices (IED)	CO1	T2: 2.1,3
8	communication network, SCADA server	CO2	T1:4.3,T2:5.2
9	SCADA / HMI systems	CO2	T2:2.6
10	SCADA architecture	CO2	T2:2.2
11	Types, advantages and disadvantages of each system	CO32	T2:2.2.3
12	single unified standard architecture-IEC 61850	CO3	T2: 2.2.4
13	SCADA Communication	CO3	T2:2.3
14	Various industrial communication technologies	CO3	T2:2.4
15	wired and wireless methods, fiber optics	CO3	T2:9.1
16	open standard communication protocols	CO4	T2:9.2
17	SCADA Operation and Control	CO4	T2:9.3
18	Operation and control of interconnected power system	CO4	R2:4.2
19	Automatic substation control	CO4	R2:4.3
20	SCADA configuration	CO4	T1:6.2
21	Energy management system	CO4	T1:6.3
22	System operating states	CO4	T1:6.4
23	Principle of DC Link Control	CO4	T1:6.5
24	system security, state estimation unit	CO4	T2: 5.7
25	SCADA Applications	CO5	T1: 5.7
26	Utility applications	CO5	T1:8.5
27	Transmission and distribution sector operations	CO5	T1:14.1,
28	transmission and distribution sector operations	CO5	T2: 5.2
29	System operating states	CO4	T1:6.4
30	Principle of DC Link Control	CO4	T1:6.5

31	system security, state estimation unit	CO4	T2: 5.7
32	SCADA Applications	CO5	T1: 5.7
33	Utility applications	CO5	T1:8.5
34	Transmission and distribution sector operations	CO5	T1:14.1,
35	transmission and distribution sector operations	CO5	T2: 5.2
36	monitoring, analysis and improvement	CO5	T1:5.3,R2:7.2
37	industries	CO5	T1:5.4,R2:7.3
38	single unified standard architecture-IEC 61850	CO5	T1:5.5,R2:7.5
39	single unified standard architecture-IEC 61850	CO5	T1: 5.7
40	SCADA Applications	CO6	T1: 2.2
41	Utility applications	CO6	T1: 2.2
42	transmission and distribution sector operations	CO6	T1: 2.2
43	transmission and distribution sector operations	CO6	T1: 2.3
44	transmission and distribution sector operations	CO6	T1: 2.3
45	monitoring, analysis	CO6	T1: 9.1
46	Discuss about least squares curve fitting based algorithms	CO5	T1: 6.2
47	SCADA Applications	CO6	T1: 2.2
48	Utility applications	CO6	T1: 2.2
49	transmission and distribution sector operations	CO6	T1: 2.2
50	transmission and distribution sector operations	CO6	T1: 2.3
51	transmission and distribution sector operations	CO6	T1: 2.3
52	monitoring, analysis	CO6	T1: 9.1
53	Discuss about least squares curve fitting based algorithms	CO5	T1: 6.2
54	transmission and distribution sector operations	CO6	T1: 2.2
55	transmission and distribution sector operations	CO6	T1: 2.3
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57	monitoring, analysis	CO6	T1: 9.1
58	Discuss about least squares curve fitting based algorithms	CO5	T1: 6.2
59	monitoring, analysis	CO6	T1: 9.1
60	Discuss about least squares curve fitting based algorithms	CO5	T1: 6.2
DISCUSSION OF QUESTION BANK			
1	Mathematical Background To SCADA and PLC	CO1 CO2	-
2	Basic Elements Of Remote terminal unit	CO3	-
3	SCADA applications	CO4	-
4	SCADA industrial applications	CO5	-
5	Digital Protection Of OPen stanardard communications protocol	CO6	-

Signature of Course Coordinator **HOD,EEE**

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COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**WASTE TO ENERGY**				
Course Code	BPSC30				
Program	M.Tech				
Semester	III	EEE			
Course Type	Elective				
Regulation	IARE PG21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. K Lingaswamy, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS009	II	Environmental Studies

II COURSE OVERVIEW:

The course is designed to create environmental awareness and consciousness among the present generation to become environmental responsible citizens. The course will discuss on the municipal solid waste composition, characteristics and to improve the methods to minimize municipal solid waste generation. This course deals with methods of disposal of solid waste by thermal biochemical processes and production of energy from different types of waste sand to know the environmental impacts of all types of municipal waste. This course will discuss the overall scenario of E-Waste management in India in comparison with other countries around the globe. This course will deals with E-waste legislation and government regulations on E-waste management.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Waste to Energy	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	**x**	MOOC
x	Seminars	**x**	Others				

V EVALUATION METHODOLOGY:

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VI COURSE OBJECTIVES:
The students will try to learn:

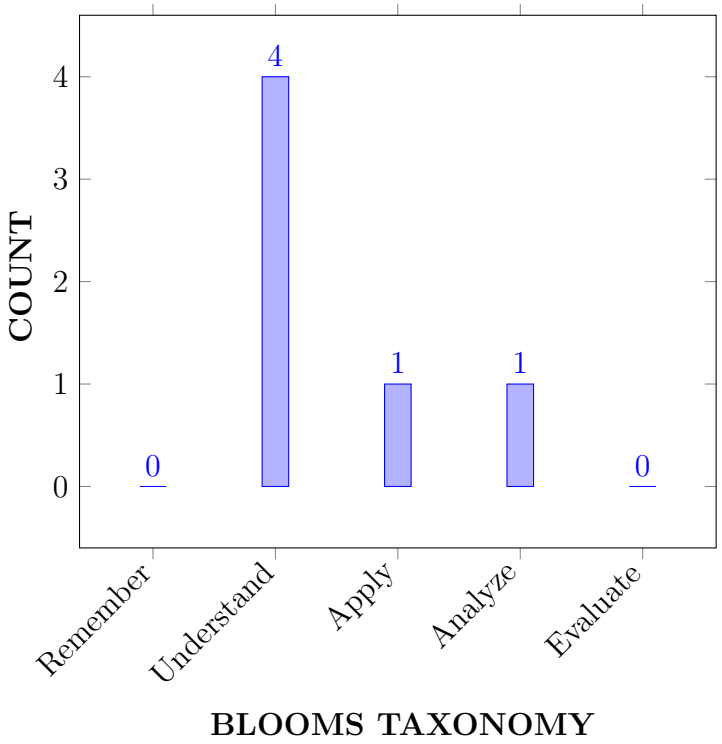
I	The principles of solid waste management in reducing and eliminating dangerous impacts of waste materials on human health and the environment to contribute economic development and superior quality of life.
II	The insight of the design and operations of a municipal solid waste landfill by collection, transfer and transportation of municipal solid waste for the final disposal.
III	The main operational challenges in operating thermal and biochemical energy from waste facilities and device processes involved in recovering energy from wastes.
IV	The scenario of E-Waste management in India and other countries around the globe and assess the impact of electronic waste on human, environment and society by informal recycling and management. The sustainable solution of E-Waste Management can be achieved by adopting modern techniques and Life-Cycle Analysis approach.

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

CO 1	**Analyze** the different sources and types of solid waste by the properties of municipal solid waste for segregation and collection of waste.	Analyze
CO 2	**Explain** the energy generation technologies from waste treatment plants and disposal of solid waste by aerobic composting and incineration process.	Understand
CO 3	**Explain** the classification, preliminary design considerations of landfill and methods of landfill disposal of solid to control greenhouse gases.	Understand

CO 4	**Understand** the Composition, characteristics of leachate to control the emission of gases by monitoring the movement of landfill leachate.	Understand
CO 5	**Outline** the Biochemical conversion of biomass for energy generation by anaerobic digestion of solid waste.	Understand
CO 6	**Apply** the knowledge in planning and operations of waste to Energy plants by following legal legislation related to solid waste management.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	2	CIE/AAT/SEE
PO 2	An ability to write and present a substantial technical report / document.	2	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	✓	-	-	-	-
CO 2	✓	✓	-	-	-	
CO 3	-	✓	-	-	-	-
CO 4	-	✓		-	-	-
CO 5	✓	-	-	-	-	-
CO 6	-	-	-	-	-	-

XI COURSE ARTICULATION MATRIX (CO – PO 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.

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	2	-	-	-	-
CO 2	1	2	-	-	-	-
CO 3	-	2	-	-	-	-
CO 4	-	2	-	-	-	-
CO 5	3	-	-	-	-	-
CO 6	-	-	-	-	-	-
TOTAL	4	4	-	-	-	-
AVERAGE	2	2	-	-	-	-

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminar and term paper	-
Laboratory Practices	-	Student Viva	-	Mini Project	-

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	**End Semester OBE Feed Back**

XIV SYLLABUS:

MODULE I	**WASTE SOURCES AND CHARACTERIZATION**
	Waste production in different sectors such as domestic, industrial, agriculture, postconsumer, waste etc. Classification of waste – agro based, forest residues, domestic waste, industrial waste (hazardous and non-hazardous). Characterization of waste for energy utilization. Waste Selection criteria
MODULE II	**TECHNOLOGIES FOR WASTE TO ENERGY**
	Biochemical Conversion – Energy production from organic waste through anaerobic digestion and fermentation. Thermo-chemical Conversion – Combustion, Incineration and heat recovery, Pyrolysis, Gasification; Plasma Arc Technology and other newer technologies..
MODULE III	**WASTE TO ENERGY AND ENVIRONMENTAL IMPLICATIONS**
	Environmental standards for Waste to Energy Plant operations and gas clean-up. Savings on nonrenewable fuel resources. Carbon Credits: Carbon foot calculations and carbon credits transfer mechanisms.
MODULE IV	**THERMO-CHEMICAL CONVERSION**
	Biogas production, land fill gas generation and utilization, thermo-chemical conversion: Sources of energy generation, gasification of waste using gasifies briquetting, utilization and advantages of briquetting, environmental benefits of bio-chemical and thermo-chemical conversion, comparison of various thermo-chemical conversion.
MODULE V	**CENTRALIZED AND DECENTRALIZED WASTE TO ENERGY PLANTS**
	Waste activities – collection, segregation, transportation and storage requirements. Location and Siting of Waste to Energy plants. Industry Specific Applications – In-house use – sugar, distillery, pharmaceuticals, Pulp and paper, refinery and petrochemical industry and any other industry. Centralized and Decentralized Energy production, distribution and use. Comparison of Centralized and decentralized systems and its operations.

TEXTBOOKS

1. Nicholas P Cheremisinoff, —Handbook of Solid Waste Management and Waste Minimization Technologies‖, An Imprint of Elsevier, New Delhi, 2003.
2. P AarneVesilind, William A Worrell and Debra R Reinhart, —Solid Waste Engineering‖, 2 nd edition 2002.
3. M Dutta , B P Parida, B K Guha and T R Surkrishnan, —Industrial Solid Waste Management and Landfilling practice‖, Reprint Edition New Delhi, 1999.
4. RajyaSabha Secretariat, —E-waste in India: Research unit‖, Reprint Edition, June, 2011.

REFERENCE BOOKS:

1. C Parker and T Roberts (Ed), —Energy from Waste‖, An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.
2. KL Shah,"Basics of Solid and Hazardous Waste Management Technology", Prentice Hall, Reprint Edition, 2000.
3. M Datta, —"Waste Disposal in Engineered Landfill", Narosa Publishing House, 1997.

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
	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	Summarize about solid waste sources and its importance.	CO 1	T1:3.3, T2:1.2, R2: 2.2
2	Discuss solid waste properties and its composition.	CO 1	T1:3.4, T2:1.4
3	Provides the information regarding collection and transfer of solid waste.	CO 1	T1:3.5, R2:1.5
4	Discuss the need of waste minimization and recycling	CO 1	T1:3.7, R2:1.8
5	Discuss the need of segregating waste and managing solid waste.	CO 1	T1: 3.9, R3: 1.10
6	Acquire the knowledge about the technologies for generation of energy from solid waste.	CO 1	T1:5.5, T2:6.2, R3:4.8
7	Acquire the knowledge about the technologies for generation of energy from biomedical waste.	CO 1	T1:5.6, T2:6.3, R3:7.5
8	Discuss the environmental impacts of incineration process.	CO 1	T1:4.3, T2:5.2, R2: 5.7
9	Illustrate the importance of landfill method of disposal.	CO 1	T1: 4.4, R1:3.3
10	Discuss the types of land fill disposal and classification of land fill sites.	CO 1	T1:4.5, T2: 5.4, R3: 7.3
11	Analyze the layout and preliminary design of landfills.	CO 2	T1:4.6, T2:5.5
12	Summarize the properties and characteristics of landfills.	CO 2	T1: 4.5.2., T2: 5.6

13	Acquire the knowledge of generating energy from landfills.	CO 2	T1:4.6, T2:5.5
14	Discuss the emission of gasses and leach ate from landfills.	CO 2	T1:4.6.2, T2:5.5.2
15	Discuss the environmental monitoring system for land fill gases.	CO 2	T1:4.7, T2:5.6
16	Discuss about the biochemical conversion and their advantages.	CO 2	T1:4.7, T2:5.8
17	Illustrate the sources of biochemical conversion process.	CO 2	T1:4.7.2, T2:5.8.2
18	Analyze anaerobic digestion of sewage and municipal waste.	CO 2	T1:4.8, T2:5.9
19	Analyze direct combustion of Municipal solid waste.	CO 2	T1:4.9, T2:5.7
20	Discuss about refuse derived solid fuel and their importance in energy generation.	CO 3	T1:6.2, T2:5.6
21	Discuss about industrial waste and agro residues.	CO 3	T1:6.3, T2:5.7
22	Understand the concept of Thermo-chemical Conversion.	CO 3	T1:6.4, T2:5.8
23	Discuss about Biogas production and generation of energy by Biogas.	CO 3	T1:6.5, T2:5.3
24	Explain the land fill gas generation and utilization of landfill gas for various purposes.	CO 3	T1:6..6, T2:5.2
25	Illustrate sources of thermo chemical energy generation	CO 3	T1:6.7, T2:5.3
26	Explain gasification of waste using gasifies briquetting process.	CO 3	T1:6.5, T2:7.5
27	Discuss utilization of various municipal solid wastes by recycling, refuse and reuse techniques.	CO 3	T1: 6.2, 6.3, R2: 7.9
28	Discuss advantages and disadvantages of briquetting process.	CO 3	T1: 6.2
29	Summarize environmental benefits of bio-chemical conversion	CO 4	T1:6.2, T2:7.2
30	Summarize environmental benefits of thermo- chemical conversion	CO 4	T1:6.3, T2:7.3
31	Outline the Growth of electrical and electronics industry in India.	CO 4	T1:6.4, T2:7.5
32	Summarize the E-waste generation in India and in the global context.	CO 4	T1: 6.2, T2: 5.6
33	Understand the Growth of E waste generated from electrical and electronics industry in India	CO 4	T1:6.3, T2: 5.7
34	Identify environmental concerns and health hazards	CO 4	T1:6.4, T2:5.8

35	Determine recycling concept of E-Waste and advantages of E-waste.	CO 5	T1:2.1, T2:9.1
36	Discuss A thriving economy of the unorganized sector of E-waste	CO 5	T1:2.2, T2:9.2
37	Discuss the global trade in hazardous waste and their impact on the environment	CO 5	T1: 2.1, R2: 9.1
38	Discuss impact of hazardous E-waste in India and effects on human health	CO 5	T1:2.6, R1:5.1
39	Understand the management processes of E-waste and the importance of formal recycling of E-waste	CO 5	T1:2.7, R1:5.2
40	Outline E-waste legislation for the recycling and disposal	CO 5	T1:2.8, R1:5.5
41	Summarize government regulations on E-waste management	CO 5	T1:2.1, R1:5.6
42	Outline international E-waste management and the guidelines imposed for formal disposal	CO 5	T1:2.2, R1:5.4
43	Explain the need for stringent health safeguards of human health and their effects	CO 5	T1:2.4,R1:5
44	Discuss the need for environmental protection laws and	CO 5	T1:2.4, R1:5.5
45	Outline environmental protection laws of India with respect to E-waste management.	CO 5	T1:2.4, R1:5.5
46	Summarize about solid waste sources and its importance.	CO 6	T1:3.3, T2:1.2, R2: 2.2
47	Discuss solid waste properties and its composition.	CO 6	T1:3.4, T2:1.4
48	Provides the information regarding collection and transfer of solid waste.	CO 6	T1:3.5, R2:1.5
49	Discuss the need of waste minimization and recycling	CO 6	T1:3.7, R2:1.8
50	Discuss the need of segregating waste and managing solid waste.	CO 6	T1: 3.9, R3: 1.10
51	Acquire the knowledge about the technologies for generation of energy from solid waste.	CO 6	T1:5.5, T2:6.2, R3:4.8
52	Acquire the knowledge about the technologies for generation of energy from biomedical waste.	CO 6	T1:5.6, T2:6.3, R3:7.5
53	Discuss the environmental impacts of incineration process.	CO 6	T1:4.3, T2:5.2, R2: 5.7
54	Illustrate the importance of landfill method of disposal.	CO 6	T1: 4.4, R1:3.3

55	Discuss the types of land fill disposal and classification of land fill sites.	CO 6	T1:4.5, T2: 5.4, R3: 7.3
55	Analyze the layout and preliminary design of landfills.	CO 6	T1:4.6, T2:5.5
56	Summarize the properties and characteristics of landfills.	CO 6	T1: 4.5.2., T2: 5.6
57	Acquire the knowledge of generating energy from landfills.	CO 6	T1:4.6, T2:5.5
58	Discuss the emission of gasses and leach ate from landfills.	CO 6	T1:4.6.2, T2:5.5.2
59	Discuss the environmental monitoring system for land fill gases.	CO 6	T1:4.7, T2:5.6
60	Summarize the properties and characteristics of landfills.	CO 6	T1: 4.5.2., T2: 5.6
DISCUSSION OF QUESTION BANK			
61	Module: I-Waste sources and characterization	CO 1	T1
62	Module: II- Technologies for waste to energy	CO 2	T2, R1
63	Module: III- Waste to energy and implications	CO3,4	R1
64	Module: IV- Thermo chemical conversion	CO 5	R2
65	Module: V-Centralized and decentralized waste to energy	CO 6	T2

Signature of Course Coordinator **HOD, EEE**
Mr.Lingaswamy, Assistant Professor