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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**ENGLISH**				
Course Code	AHSC01				
Program	B. Tech				
Semester	I				
Course Type	Foundation				
Regulation	UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	-	2	-	-
Course Coordinator	Ms.Waheeda Begum Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

II COURSE OVERVIEW:

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

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

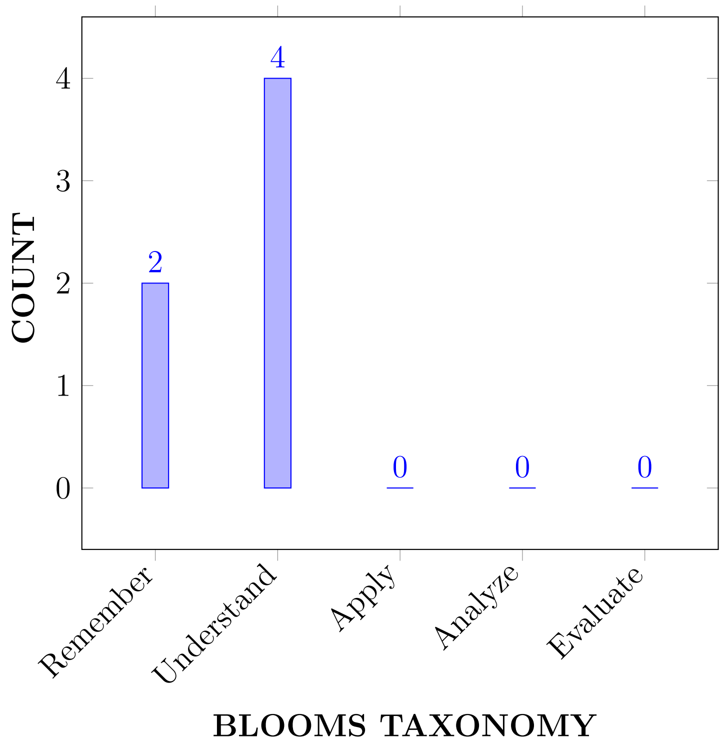
I	Standard pronunciation, appropriate word stress, and necessary intonation patterns for effective communication towards achieving academic and professional targets.
II	Appropriate grammatical structures and also using the nuances of punctuation tools for practical purposes.
III	A critical aspect of speaking and reading for interpreting in-depth meaning between the sentences.
IV	A conceptual awareness on writing in terms of unity, content, coherence, and linguistic accuracy.

VII COURSE OUTCOMES:

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

CO 1	**Recall** the key requirements of listening skills for personal , academic and professional purposes.	Remember
CO 2	**Interpret** soutable speaking techniques and strategies to understand the core idea of a subject clearly.	Understand
CO 3	**Illustrate** permissible language for developing life skills to overcome the challenges at professional platform.	Understand
CO 4	**Classify** the grammatical aspects effectively in speaking and writing at functional usage.	Understand
CO 5	**Describe** the significance of reading skills and various strategies to enhance professional success.	Remember
CO 6	**Compare** the writing skills for accomplishing the academic and non-academic demands of various written communicative functions.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.Build Embedded Software and Digital Circuit Development platform for Robotics, Embedded Systems and Signal Processing Applications..	-	-
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	-	-
PSO3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	-	-

3 = High; 2 = Medium; 1 = Low

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

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

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

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

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

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

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

TEXTBOOKS

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

REFERENCE BOOKS:

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

XIX COURSE PLAN:

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

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

35	Organizing principles of a paragraph in documents and types of paragraphs.	CO 5	T1:101.103
36	Writing introduction and conclusion.	CO 5	T1:103.103
37	Techniques for writing precis.	CO 6	T1:103.103
38	Introduction to informal letters.	CO 5	TI:105.108
39	Introduction to formal letters.	CO 5	TI:109.110
40	Introduction of email writing and formal and informal emails.	CO 5	TI:111.112
41	Significance of Report Writing.	CO 6	TI: 113. 114
PROBLEM SOLVING/ CASE STUDIES			
42	The aspects to improve listening comprehension Discuss in detail.	CO 1	TI:10,11
43	Different types of listeners with examples.	CO 1	TI: 19,21
44	The sounds of English language	CO 1	TI:23,27
45	verbal communication or written communication.	CO 2	TI: 27,30
46	Various difficulties in public speaking.	CO 2	TI: 32,33
47	Different ways of greeting people in formal and informal situation and discuss how do they matter in communication?	CO 2	TI: 35,37
48	‘Oral presentation requires a good planning’.	CO 2	TI:36,38
49	Power point presentation and the ways to make Power point presentation.	CO 2	TI: 37,38
50	Methods that are used to establish the process of building vocabulary with examples from the most used words in spoken English.	CO 4	TI:39,41
51	The usage of idioms and phrases in spoken English.	CO 4	TI: 47,50
52	‘Structure proposition-evaluation’ -Reading technique.	CO 5	TI:56,58
53	Active reading, detailed reading, and speed-reading techniques used in different situations.	CO 5	TI: 79,81
54	The elements of paragraph writing in detail.	CO 6	TI:100,102
55	Logical bridges and Verbal bridges in writing.	CO 6	TI:102,104
56	Soft skills and Interpersonal Communication.	CO 6	TI:102,104
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Soft skills and Interpersonal Communication.	CO 1	TI 8,9
58	Language acquisition is a process.	CO 1	TI: 11,12
59	Communication.	CO 1	TI: 14,16
60	Time management.	CO 3	TI:9,10
61	Stress management.	CO 3	TI:9,10

DISCUSSION OF QUESTION BANK			
62	Soft Skills for difficult situations in terms of reassurance and reliability.	CO 3	TI:9,10
63	Verbal and non-verbal communication.	CO 2	TI: 34,35
64	Honesty, Respect, Self-Control and Accountability their role in building long lasting interpersonal skills?	CO 3	TI: 9,10
65	Etiquette and manners. Its importance in social, personal and professional communication.	CO 3	TI: 9,10
66	Problem solving and decision making.	CO 3	TI: 9,10

Signature of Course Coordinator **HOD**

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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**
Course Title	**LINEAR ALGEBRA AND CALCULUS**
Course Code	AHSC02
Program	B.Tech
Semester	I
Course Type	Foundation
Regulation	UG - 20

Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. P Shantan Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

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

II COURSE OVERVIEW:

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

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Linear Algebra and Calculus	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

10 %	Remember
30 %	Understand
60 %	Apply
0 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):

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

<table>
<tr><th colspan="2">Component</th><th>Marks</th><th>Total Marks</th></tr>
<tr><td rowspan="4">CIA</td><td>Continuous Internal Examination – 1 (Mid-term)</td><td>10</td><td rowspan="4">30</td></tr>
<tr><td>Continuous Internal Examination – 2 (Mid-term)</td><td>10</td></tr>
<tr><td>AAT-1</td><td>5</td></tr>
<tr><td>AAT-2</td><td>5</td></tr>
<tr><td>SEE</td><td>Semester End Examination (SEE)</td><td>70</td><td>70</td></tr>
<tr><td colspan="3">Total Marks</td><td>100</td></tr>
</table>

Continuous Internal Examination (CIE):

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

Alternative Assessment Tool (AAT)

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

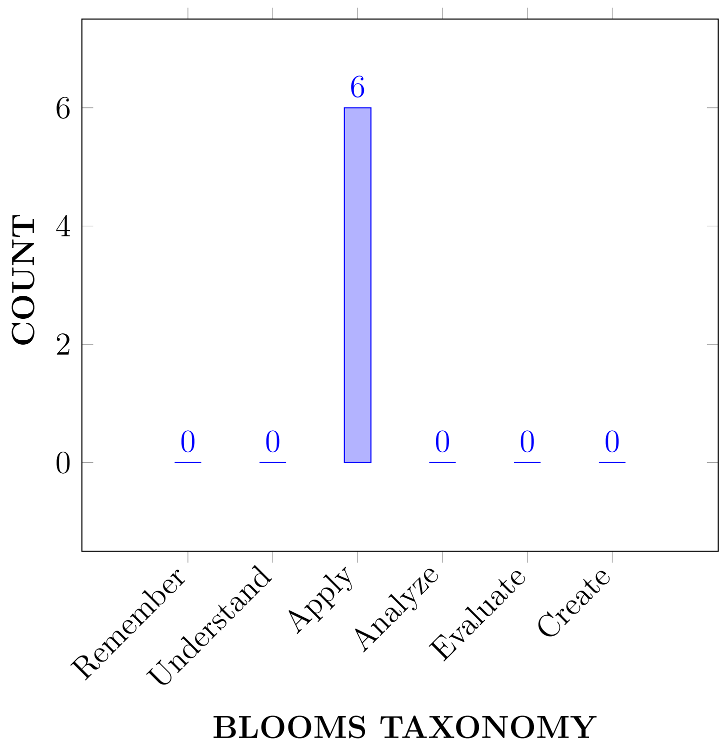
I	The principles of Eigen value analysis and linear transformations, Matrix rank finding methods.
II	The calculus of functions of several variables and the concept of maxima-minima for a three-dimensional surface.
III	The analytical methods for solving higher order differential equations with constant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

VII COURSE OUTCOMES:

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

CO 1	**Compute** the rank and inverse of real and complex matrices with elementary transformation methods.	Apply
CO 2	**Use** the Eigen values, Eigen vectors for developing modal and Spectral matrices from the given matrix..	Apply
CO 3	**Make use of** Cayley Hamilton theorem for finding positive and negative powers of the matrix.	Apply
CO 4	**Utilize** the mean–value theorems and partial derivatives in estimating the extreme values for functions of several variables	Apply
CO 5	**Solve** the Second and higher order linear differential equations with constant coefficients by using substitution and method of variation of parameters..	Apply
CO 6	**Apply** the Fourier Series expansion of periodic, even and odd functions in analyzing the square wave, sine wave rectifiers.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	-	-
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	-	-

PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	-	-

3 = High; 2 = Medium; 1 = Low

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

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

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	**Explain** the role of rank and inverse of real and complex matrices in solving **complex engineering problems** by using elementary transformation methods **(principles of mathematics).**	2
CO 2	PO 1	**Determine** the Eigen values, Eigen vectors, Spectral matrix **complex engineering problems modeled by matrices** with help of Characterstic Equation **(principles of mathematics).**	2
	PO 2	**Model** the problem into matrices, prepare precise **statement** of the problem and apply the concepts of Eigen values and Eigen vectors to **develop the solution** and **interpret, validate** the results through proper **documentation**	6
CO 3	PO 1	**Make use of** Cayley Hamilton theorem for finding positive and negative powers of the matrix and apply them in the **complex engineering problems** modeled by matrices **(principles of mathematics).**	2
CO 4	PO 1	**Explain** the mean–value theorems for the single variable functions andthe extreme values for functions of several variables apply them in the **complex engineering problems** Ordinary and Partial derivatives .	2

CO 5	PO 1	**Determine**the solution of **complex engineering problems** modeled by Second and higher order linear differential equations with constant coefficients by using substitution method and method of variation of parameters.	2
	PO 2	**Model** the problem with the help of ordinary differential equations, prepare precise **statement** of the problem and apply method of variation of parameters and other analytical methods to **develop the solution** and **interpret, validate** the results through proper **documentation**	6
CO 6	PO 1	**Build** the Fourier series expansion **for the complex engineering problems** modeled by given periodic, even and odd functions in various intervals with the help of Fourier coefficients formulae **(principles of mathematics).**	2
	PO 2	**Model** the problem with the help of suitable periodic functions, prepare precise **statement** of the problem and apply Fourier series expansions to **develop the solution** and **interpret, validate** the results through proper **documentation**	6

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

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

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

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	67	60	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	67	60	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	67	60	-	-	-	-	-	-	-	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	-	Seminars	-
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-	Tech - talk	✓	Concept Video	PO 1, PO 2	-	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

x	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	THEORY OF MATRICES
	Real matrices: Symmetric, Skew-Symmetric and Orthogonal matrices; Complex matrices: Hermitian, Skew- Hermitian and Unitary matrices; Elementary row and column transformations, finding rank of a matrix by reducing to Echelon form and Normal form; Finding the inverse of a matrix using Gauss-Jordan method

MODULE II	**LINEAR TRANSFORMATIONS**
	Cayley-Hamilton theorem: Statement, verification, finding inverse and powers of a matrix; Linear dependence and independence of vectors; Linear transformation; Eigen values and Eigen vectors of a matrix; Diagonalization of matrix.
MODULE III	**FUNCTIONS OF SINGLE AND SEVERAL VARIABLES**
	Mean value theorems: Rolle's theorem, Lagrange's theorem, Cauchy's theorem-without proof; Functions of several variables: Partial differentiation, Jacobian, functional dependence, maxima and minima of functions with two variables and three variables. Method of Lagrange multipliers.
MODULE IV	**HIGHER ORDER LINEAR DIFFERENTIAL EQUATIONS**
	Linear differential equations of second and higher order with constant coefficients. Non-homogeneous term of the type f(x) = e^{ax} , sinax , cosax , x^n , e^{ax}v(x) and Method of variation of parameters.
MODULE V	**FOURIER SERIES**
	Fourier expansion of periodic function in a given interval of length $2\pi; Fourierseriesofevenandoddfunctions; Fourierseriesinanarbitraryinterval;$

TEXT BOOKS

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

REFERENCE BOOKS:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9^{th} Edition, John Wiley & Sons, 2006.
2. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
3. D. Poole, Linear Algebra: A Modern Introduction, 2^{nd} Edition, Brooks/Cole, 2005.

WEB REFERENCES:

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

COURSE WEB PAGE:

1. lms.iare.ac.in

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Outcome based education	-	-
CONTENT DELIVERY (THEORY)			
2	Theory of Matrices: Types of Real Matrices	CO 1	T2:32.1 R1:4.1
3	Real Matrices: Symmetric, Skew-Symmetric Matrices	CO 1	T2:32.1 R1:4.2
4	Real Matrices: Orthogonal Matrices	CO 1	T2:32.1 R1:4.3
5	Complex Matrices: Hermitian, Skew- Hermitian	CO 1	T2:32.1 R1:4.3
6	Complex Matrices: Unitary Matrices	CO 1	T2:32.5 R1:4.6
7	Elementary Operations: Elementary Row and Column Transformations	CO 1	T2:32.5 R1:4.6
8	Rank of a Matrix by Echelon Form	CO 1	T2:32.4 R1:4.5
9	Rank of a Matrix by Normal Form	CO 1	T2:32.7 R1:4.8
10	Inverse of a Matrix by Gauss-Jordan Method	CO 1	T2-7.1 R1:7.4
11	Eigen Values of a Matrix	CO 2	T2-7.1 R1:7.4
12	Eigen Vectors of a Matrix	CO 2	T2-7.1 R1:7.4
13	Diagonalization of Matrix by Linear Transformation.	CO 2	T2:7.1 R1:7.4
14	Cayley-Hamilton Theorem- Statement, Verification	CO 3	T2:7.1 R1:7.4
15	Applications of Cayley – Hamilton: Finding Inverse and Powers of a Matrix	CO 3	T3-2.9 R1:2.1
16	Linear Dependence and Independence of Vectors	CO 2	T3-2.5 R1:2.8
17	Mean Value Theorems:1: Rolle's Theorem	CO 4	T3-2.5 R1:2.8
18	Mean Value Theorems:2: Lagrange's Theorem	CO 4	T3-2.5 R1:2.8
19	Mean Value Theorems:3: Cauchy's Theorem	CO 4	T3-2.5 R1:2.8

20	Functions of Several Variables: Partial Differentiation	CO 4	T3-2.5 R1:2.8
21	Jacobian Transformations	CO 4	T3-2.61 R1:2.10
22	Functional Dependence	CO 4	T1-7.1 R2:7.5
23	Maxima and Minima of Functions with Two Variables	CO 4	T3-2.61 R1:2.10
24	Maxima and Minima of Functions with Three Variables	CO 4	T1-7.1 R2:7.6
25	Application Method of Lagrange Multipliers	CO 4	T1-7.1 R2:7.7
26	Method of Lagrange Multipliers	CO 4	T3-2.5 R1:2.8
27	Linear Differential Equations of Second and Higher Order with Constant Coefficients	CO 5	T3-2.5 R1:2.8
28	Linear Differential Equations of Second and Higher Order with Constant Coefficients	CO 5	T3-2.5 R1:2.8
29	Non-Homogeneous term of the type F (X) = e^{ax}	CO 5	T3-2.5 R1:2.8
30	Non-Homogeneous term of the type F (X) = Sinax , Cosax	CO 5	T2-7.1 R1:7.4
31	Non-Homogeneous term of the type F (X) = X^n	CO 5	T2:7.1 R1:7.4
32	Non-Homogeneous term of the type F (X) = e^{ax}v(X)	CO 5	T2:7.1 R1:7.4
33	Method of Variation of Parameters	CO 5	T3-2.9 R1:2.1
34	Fourier Expansion of Periodic Function in a Given Interval of Length 2π	CO 6	T3-2.5 R1:2.8
35	Fourier Expansion of Periodic Function in a Given Interval of Length (-π, π)	CO 6	T3-2.5 R1:2.8
36	Fourier Series of Even Functions in a Given Interval of Length (-π, π)	CO 6	T2:7.1 R1:7.4
37	Fourier Series of Odd Functions in a Given Interval of Length (-π, π)	CO 6	T3-2.9 R1:2.1
38	Fourier Series in an Arbitrary Interval (0,2l)	CO 6	T3-2.5 R1:2.8
39	Fourier Series in an Arbitrary Interval (-l,l)	CO 6	T2:7.1 R1:7.4
40	Half- Range Fourier Sine Expansions in a Given Interval of Length (0,π)	CO 6	T3-2.9 R1:2.1
41	Half- Range Fourier Cosine Expansions in a Given Interval of Length (0,π)	CO 6	T3-2.5 R1:2.8

PROBLEM SOLVING/ CASE STUDIES			
42	Rank of the Matrix by Echelon and Normal Form	CO 1	T2:32.1 R1:4.2
43	Eigen Values and Eigen Vectors of The Matrix	CO 2	T2:32.1 R1:4.3
44	Finding Powers of the Matrix by Cayley Hamilton Theorem	CO 3	T2:32.1 R1:4.3
45	Finding Spectral Matrix by Linear Transformation.	CO 2	T2-7.1 R1:7.4
46	Jacobian Transformation in Cartesian and Polar Forms	CO 4	T2-7.1 R1:7.4
47	Finding Functional Relationship.	CO 4	T2:7.1 R1:7.4
48	Finding Critical Points.	CO 4	T2:7.1 R1:7.4
49	Solving Non-Homogeneous Differential Equations.	CO 5	T3-2.5 R1:2.8
50	Solving Second Order Non-Homogeneous Differential Equations by Method of Variation of Parameters.	CO 5	T3-2.5 R1:2.8
51	Finding Fourier Series	CO 6	T3-2.5 R1:2.8
52	Fourier Expansion of Periodic Function in a Given Interval of Length 2π	CO 6	T3-2.5 R1:2.8
53	Fourier Expansion of Periodic Function in a Given Interval of Length $(-\pi, \pi)$	CO 6	T3-2.61 R1:2.10
54	Fourier Series in An Arbitrary Interval (-l,l)	CO 6	T2:7.1 R1:7.4
55	Finding Fourier Sine Series in Interval (0,l)	CO 6	T3-2.9 R1:2.1
56	Finding Fourier Cosine Series in Interval (0,l)	CO 6	T3-2.5 R1:2.8
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Real, Complex Matrices and Rank of a Matrix	CO 1	T3-2.5 R1:2.8
58	Eigen Values and Eigen Vectors, Diagonalization	CO 2,C0 3	T3-2.5 R1:2.8
59	Mean Value Theorems, Jacobian Transformations, Functionally Dependent and Independent	CO 4	T3-2.5 R1:2.8
60	Higher Order Differential Equations	CO 5	T3-2.5 R1:2.8
61	Fourier Series (Even, Odd, Neither Functions)	CO 6	T3-2.61 R1:2.10

DISCUSSION OF QUESTION BANK			
62	Theory of Matrices	CO 1	T2:7.1 R1:7.4
63	Linear Transformations	CO 2,C0 3	T3-2.9 R1:2.1
64	Functions of Several Variables	CO 4	T3-2.5 R1:2.8
65	Higher Order Differential Equations	CO 5	T2:32.1 R1:4.3
66	Fourier Series.	CO 6	T2-7.1 R1:7.4

Signature of Course Coordinator **HOD, ME**
Mr. P Shantan Kumar, Assistant Professor

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

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**ENGINEERING PHYSICS**				
Course Code	AHSC03				
Program	B.Tech				
Semester	I	AE/CE/ECE/EEE/ME			
Course Type	Foundation				
Regulation	IARE - UG 20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	4	3	1.5
Course Coordinator	Ms.Sujani Singavarapu, Assistant Professor				

I COURSE PRE-REQUISITES:

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

II COURSE OVERVIEW:

This course is structured specifically to make the students understand some of the core topics in physics essential for further studies in engineering. It focuses on illustrating and developing an understanding of the interplay between problem solving and their practical applications which include experimental techniques and modern equipment. The topics include quantum mechanics, semiconductors, LASER and fiber optics,light and optics, harmonic oscillations and waves in one dimension. At the end, this course helps students to appreciate the diverse real-time applications in technological fields in respective branches.

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
0 %	Remember
66.7 %	Understand
33.3 %	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. **Alternative Assessment Tool (AAT):**

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

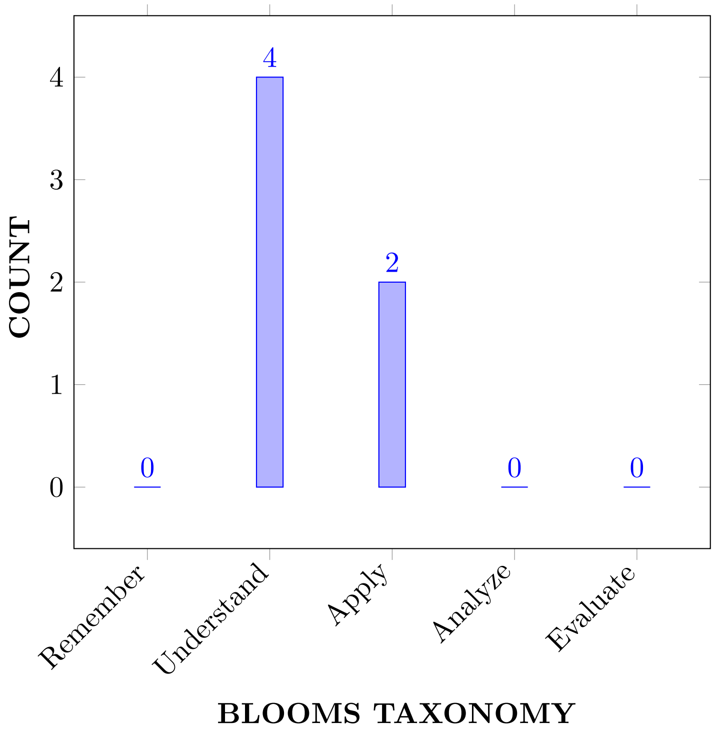
I	Basic formulations in wave mechanics for the evolution of energy levels and quantization of energies for a particle in a potential box with the help of mathematical description.
II	Fundamental properties of semiconductors including the band gap, charge carrier concentration, doping and charge carrier transport mechanisms.
III	Simple optical setups and experimental approaches of light and LASER using its interaction with matter.
IV	Basic comparative studies between different harmonic oscillators and different waves using such relationships on practical problems. .

VII COURSE OUTCOMES:

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

CO 1	**Apply** the concepts of dual nature of matter and Schrodinger wave equation to a particle enclosed in simple systems.	Understand
CO 2	**Demonstrate** the classification of solids and important aspects of semiconductors in terms of carrier concentration and Fermi level.	Apply
CO 3	**Compare** the concepts of LASER and normal light in terms of mechanism and working principles for applications in various fields and scientific practices.	Understand
CO 4	**Explain** functionality of components in optical fiber communication system by using the basics of signal propagation, attenuation and dispersion.	Understand
CO 5	**Interpret** the phenomenon of interference and diffraction by using the principles of wave motion and superposition.	Understand
CO 6	**Make use of** the concept of simple harmonic motion and arrive at expressions for damped, forced harmonic oscillators and wave equations by using necessary mathematical formulations.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of computational and experimental tools for building career paths towards innovative startups, employability and higher studies.	1	Laboratory experiments

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH POs, PSOs:

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

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	**Outline** drawbacks of classical mechanics,basic principles of dual nature of matter wave,derive mathematical equation of matter waves and come to conclusion of quantization of energy used in quantum dots.	3
	PO 2	**Explain** the given **problem statement** and **formulate** quantum confinement problems related to particle enclosed in small dimension from the provided **information** and **data** in reaching substantial conclusions by the **interpretation of results**	4
	PSO 3	**Make use of** the knowledge of **quantum mechanics in experimental tools.**	1
CO 2	PO 1	**Illustrate** the charge transport mechanism in intrinsic and extrinsic semiconductors using energy level diagrams,calculate their charge carrier concentration and use those expressions to integrate with other engineering disciplines.	3

	PO 2	**Explain** the given problem statement and formulate mobility and conductivity aspects of a material from the provided information and data in reaching substantial conclusions **by the interpretation** of **Hall coefficient value.**	4
	PO 4	**Identify** the use of semiconductors under study and their conduction mechanism for the **research based knowledge** and **technological development.**	2
CO 3	PO 1	**Compare** the concepts of LASER and normal light in terms of mechanism and **working principles** for **applications** in different fields and **scientific practices.**	3
CO 4	PO 1	**Explain** functionality of components in optical fiber communication **system** by using the **basics** of signal propagation, attenuation and dispersion.	3
	PO 2	**Identify the given problem** and **formulate** expressions for acceptance angle and numerical aperture with the given **information and data** by applying principles of information propagation through optical wave guides.	4
CO 5	PO 1	**Outline** the **scientific principles** of light and its propagation evolution of different theories, and use the principles of wave motion and superposition using **mathematical principles** to understand the interference and diffraction phenomena in light	3
	PO 4	**Explain** from **technical literature the knowledge of the equipment** on which scientists performed experiments to understand the superposition of light and pattern formation by relating it to conditions for constructive and destructive interference.	2
CO 6	PO 1	**Outline** the basic **scientific principles** of force and characteristics of a simple harmonic oscillator to understand the forces acting on given oscillator to arrive at equations of damped,forced oscillators and wave equations using basic **mathematical principles**	3
	PO 2	**Explain** how damping and forced oscillations happen in a system and **identify the problems** and advantages for different conditions of damping.	4

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

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	40	-	-	-	-	-	-	-	-	-	-	-	-	35
CO 2	100	40	-	18	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	100	-	-	18	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

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

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Term Paper	-	Concept Video	✓	Open Ended Experiments	-
Tech Talk	✓	Assignments	-		

XVII ASSESSMENT METHODOLOGY INDIRECT:

X	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**QUANTUM MECHANICS**
	Introduction to quantum physics, De-broglie's hypothesis, Wave-particle duality, Davisson and Germer experiment, Time-independent Schrodinger equation for wave function, Physical significance of the wave function, Schrodinger equation for one dimensional problems–particle in a box.
MODULE II	**INTRODUCTION TO SOLIDS AND SEMICONDUCTORS**
	Introduction to classical free electron theory and quantum theory, Bloch's theorem for particles in a periodic potential (Qualitative treatment), Kronig-Penney model (Qualitative treatment), classification: metals, semiconductors, and insulators. Intrinsic and extrinsic semiconductors, Carrier concentration, Dependence of Fermi level on carrier-concentration and temperature, Hall effect
MODULE III	**LASERS AND FIBER OPTICS**
	Characteristics of lasers, Spontaneous and stimulated emission of radiation, Metastable state, Population inversion, Lasing action, Ruby laser, He-Ne laser and applications of lasers. Principle and construction of an optical fiber, Acceptance angle, Numerical aperture, Types of optical fibers (Single mode, multimode, step index, graded index), Optical fiber communication system with block diagram and Applications of optical fibers .
MODULE IV	**LIGHT AND OPTICS**
	Principle of superposition of waves, Young's double slit experiment, Fringe width, Newton's rings. Fraunhofer diffraction from a single slit, double slit (extension to N slits) and diffraction grating experiment.
MODULE V	**HARMONIC OSCILLATIONS AND WAVES IN ONE DIMENSION**
	Simple harmonic oscillator, Damped harmonic oscillator, Forced harmonic oscillator. Transverse waves and Longitudinal wave equation, Reflection and transmission of waves at a boundary, Harmonic waves.

TEXTBOOKS

1. P.K.Palanisamy, "Engineering Physics", SCITECH publications, 2nd Edition,2010.
2. R. K. Gaur, S. L. Gupta, "Engineering Physics", Dhanpat Rai Publications, 8th Edition, 2001.
3. Dr. K. Vijaya Kumar, Dr. S. Chandralingam, "Modern Engineering Physics", Chand & Co. New Delhi, 1st Edition, 2010.
4. Manoj.K.Harbola, T.Vijaya Krishna, T. Madhu Mohan," Engineering Physics", Cengage Publications,1st Edition, 2010.

REFERENCE BOOKS:

1. H.J. Pain, "The Physics of Vibrations and Waves", Wiley, 2006.
2. Ghatak, "Optics", McGraw Hill Education, 2012.
3. O. Svelto, "Principles of Lasers", Springer Science & Business Media, 2010.

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	
CONTENT DELIVERY (THEORY)			
2	Introduction to quantum physics- Black body radiation, Planck's law, Photoelectric effect, Compton effect	CO 1	T1:6.1 R1:1.12.1,
3	De-Broglie's hypothesis,	CO 1	T1:6.3 R1:1.16
4	Wave-particle duality -Matter wave concept	CO 1	T1:6.2 R1:1.13.1
5	Davisson and Germer experiment	CO 1	T1:6.4.1 R1:1.13.2
6	Time-independent Schrodinger equation for wave function	CO 1	T1:6.6 R1:1.13.3
7	Born interpretation of the wave function	CO 1	T1:6.6.1 R1:1.17.1
8	Schrodinger equation for one -dimensional problems– particle in a box.	CO 1	T1:6.7 R1:1.17.3
9	Introduction to classical free electron theory & quantum theory.	CO 2	T1:7.2 R1:1.17.3
10	Bloch's theorem for particles in a periodic potential,	CO 2	T1:7.4 R1:2.3
11	Kronig-Penney model (Qualitative treatment)	CO 2	T1:7.5 R1:2.3
12	Types of electronic materials: metals, semiconductors, and insulators	CO 2	T1:7.6,7.7 R1:2.6.2
13	Intrinsic semiconductors - concentration of electrons in conduction band.	CO 2	T1:8.3.1 R1:2.8
14	Intrinsic semiconductors - concentration of holes in valence band	CO 2	T1:8.3.2 R1:2.9.2
15	Extrinsic semiconductors- Carrier concentration in N-Type	CO 2	T2:8.5 R1:2.10
16	Extrinsic semiconductors- Carrier concentration in P-Type	CO 2	T1:8.6 R1:2.10
17	Dependence of Fermi level on carrier-concentration and temperature	CO 2	T1:8.5,8.6 R1:2.10.2
18	Hall effect	CO2	T1:8.9 R1:2.32
19	Introduction and characteristics of LASER	CO 3	T1:12.1. R1:8.2

20	Spontaneous and stimulated emission of radiation,Meta stable state, Population inversion, Lasing action	CO 3	T1:12.2 R1:8.3.3
21	Ruby laser,He-Ne laser	CO 3	T1:12.3,12.8 R1:8.7.2
22	Applications of LASER	CO 3	T1:12.8.12.9 R1:8.7.2
23	Principle and construction of an optical fiber	CO 4	T1:13.2 R2:12.24
24	Acceptance angle, Numerical aperture	CO 4	T1:13.2 R3:12.25
25	Types of optical fibers (Single mode, multimode, step index, graded index)	CO 4	T1:13.3 R3:3.2
26	Optical fiber communication system with block diagram	CO 4	T1:13.7 R3:3.2
27	Applications of optical fibers .	CO 4	T1:13.12 R1:8.10
28	Principle of Superposition of waves	CO 5	T4:4.3 R1:8.11.1
29	Young's double slit experiment	CO 5	T4:4.7 R1:8.11.2
30	Newton's rings	CO 5	T4:4.14 R1:8.12.1
31	Fraunhofer diffraction from a single slit	CO 5	T4:4.19 R1:8.12.2
32	Fraunhofer diffraction from a Double slit	CO 5	T4:4.21 R1:8.20
33	Fraunhofer diffraction from diffraction grating	CO 5	T4:4.22 R1:8.19
34	Simple Harmonic Oscillators	CO 6	T4:2.3 R1:8.77
35	Damped harmonic oscillator	CO 6	T4:2.8,2.9 R1:7.2
36	Forced mechanical oscillators	CO 6	T4:2.14 R1:7.7
37	Impedance, Steady state motion of forced damped harmonic oscillator	CO 6	T4:2.17 R1:7.8
38	Transverse wave on a string, the wave equation on a string	CO 6	T4:3.3 R1:7.9.2
39	Longitudinal waves and the wave equation	CO 6	T4:3.7 R1:7.9.1
40	Reflection and transmission of waves at a boundary	CO 6	T4:3.4 R1:7.10
41	Harmonic waves	CO 6	T4:3.6 R1:7.11, 11.1

PROBLEM SOLVING/ CASE STUDIES			
1	De-Broglie hypothesis-wavelength expression	CO 1	T1:6.3 R1:1.161
2	Schrodinger equation for one dimensional problems–particle in a box.	CO 1	T1:6.6 R1:1.161
3	Physical significance of the wave function	CO 1	T1: 6.6.1 R1:1.161.
4	Carrier concentration	CO 2	T1:8.3-6, R1:2.8,2.10
5	Fermi level	CO 2	T1:8.5,8.6 R1: 2.10
6	Hall Effect	CO 2	T1:8.9, R1: 2.32
7	Lasers	CO 3	T1: 12.3 R3:12.26
8	Acceptance angle & Numerical aperture	CO 4	T1: 13.2 R3:12.26
9	Refractive indices of core and cladding, fractional refractive index change	CO 4	T1: 13.3 R3:12.26
10	Youngs double-slit	CO 5	T4: 4.7 R1:8.12.1
11	Fringe width	CO 5	T4: 4.7 R1:8.12.1
12	Newton rings	CO 5	T4: 4.14 R1:8.12.1
13	Diffraction grating	CO 5	T4: 4.22 R1:8.12.1
14	Simple Harmonic Oscillator	CO 6	T4:2.3 R1: 8.78
15	Harmonic waves	CO 6	T4:3.6 R1: 7.9.3
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Quantum mechanics	CO 1	T1:6.1-6.7 R1:1.161.
2	Introduction to Solids and Semiconductors	CO 2	T1:7.2-7, 8.3-9 , R1: 2.8, 2.10
3	Lasers and Fiber Optics	CO 3, CO 4	T1: 12.1-12.9,13.2-13.12 R3:12.26
4	Light and Optics.	CO 5	T4: 4.3-4.22 R1:8.12.1

5	Harmonic Oscillations and Waves in One Dimension	CO 6	T4:2.3-3.7 R1: 8.78, 7.9.3
DISCUSSION OF QUESTION BANK			
1	Module 1	CO 1	T1:6.1-6.7 R1:1.161.
2	Module 2	CO 2	T1:6.1-6.7 R1: 2.8, 2.10
3	Module 3	CO 3, CO 4	T1: 12.1-12.9,13.2-13.12 R3:12.26
4	Module 4	CO 5	T4: 4.3-4.22 R1:8.12.1
5	Module 5	CO 6	T4:2.3-3.7 R1: 8.78, 7.9.3

Signature of Course Coordinator **HOD,FE**
Ms.Sujani Singavarapu

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

COURSE DESCRIPTION

Department	Mechanical Engineering				
Course Title	Python Programming				
Course Code	ACSC01				
Program	B.Tech				
Semester	I	Mech			
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. B Dilip chakravarthy, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	ACSC01	I	NIL

II COURSE OVERVIEW:

This course introduces students to writing computer programs. This course presents the principles of structured programming using the Python language, one of the most increasingly preferred languages for programming today. Because of its ease of use, it is ideal as a first programming language and runs on both the PC and Macintosh platforms. However, the knowledge gained in the course can be applied later to other languages such as C and Java. The course uses iPython Notebook to afford a more interactive experience. Topics include fundamentals of computer programming in Python,object-oriented programming and graphical user interfaces.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Python Programming	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
33.3 %	Remember
50 %	Understand
16.66 %	Apply
0 %	Analyze

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

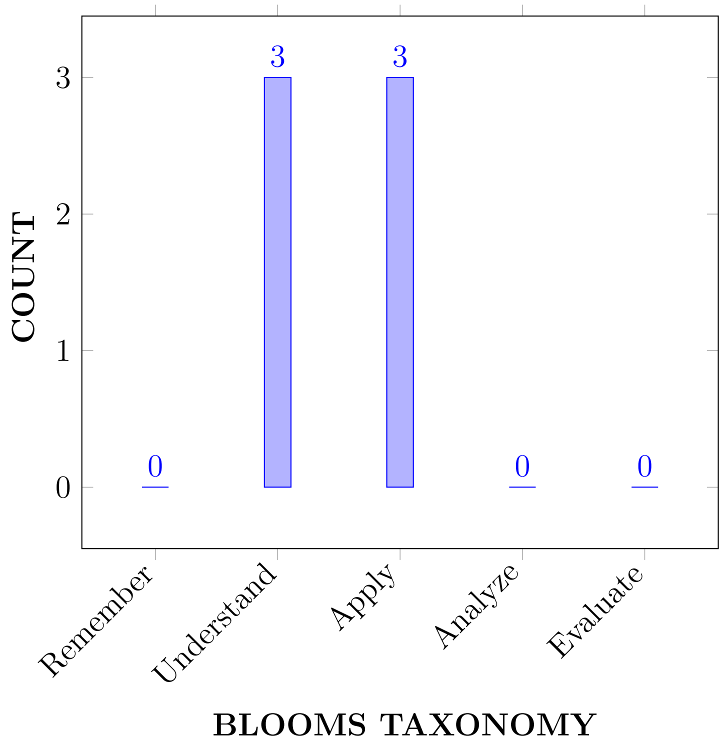
I	**Acquire programming skills in core Python**
II	**Acquire Object-oriented programming skills in Python.**
III	**Develop the skill of designing graphical-user interfaces (GUI) in Python.**
IV	**Develop the ability to write database applications in Python.**
V	**Acquire Python programming skills to move into specific branches - Internet of Things (IoT), Data Science, Machine Learning (ML), Artificial Intelligence (AI) etc.**

VII COURSE OUTCOMES:

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

CO 1	**Demonstrate** the basic concepts of python programming with the help of data types,operators, expressions, and console input/output.	Understand
CO 2	**Make use of** control statements for altering the sequential execution of programs in solving problems.	Apply
CO 3	**Demonstrate** operations on built-in container data types (list, tuple, set, dictionary) and strings.	Understand
CO 4	**Illustrate** operations and applications on strings with the help of built in functions.	Understand
CO 5	**Solve** the problems by using modular programming concepts through functions.	Apply
CO 6	**Identify** object oriented programming constructs for developing large, modular and reusable real-time programs.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	3	Tech talk /Open ended experiments
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	3	Tech talk /Open ended experiments

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Understand (knowledge) the basic concept of operators, precedence of operators and associativity while evaluating mathematical expressions in program statements. These concepts provide an insight into expression evaluation by applying the principles of mathematics and science.	3
CO 1	PO 5	With the help of modern engineering tools we can easily Understand the basic concept of operators, precedence of operators and associativity while evaluating mathematical expressions in program statements These concepts provide an insight into expression evaluation by applying the principles of mathematics and science.	1
CO 1	PO 10	Extend the knowledge of Python programming to communicate effectively with the Engineering community and society at large.	3
CO 1	PSO 1	Understand features of procedural as well as object-oriented programming while writing and analyzing computer programs in the areas related to Machine Learning, Big data and Artificial Intelligence	3
CO 2	PO 1	By applying the knowledge of mathematics,science and engineering fundameentals we can effectively use control statements.	3
CO 2	PO 2	Apply control statements in problem indentification,statement and validation .	5
CO 2	PO 3	Apply control statements to investigate and understand different complex engineering problems complex problems efficiently.	8
CO 2	PO 5	By applying control statements to model complex engineering activities	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO 10	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	3
CO 2	PSO 1	Apply features of procedural as well as object-oriented programming while writing and analyzing computer programs in the areas related to Machine Learning, Big data and Artificial Intelligence	3
CO 2	PSO 3	Acquire sufficient knowledge of object-oriented concepts and apply it in real-time for building successful career and doing higher studies.	3
CO 3	PO 1	Summarize indexing and slicing mechanisms for extracting a portion of data in a sequence using principles of mathematics, and engineering fundamentals.	3
CO 3	PO 3	Demonstrate the importance of indexing mechanisms in sequences such as lists, strings, sets, tuple and dictionary while developing solutions for complex engineering problems and design system using principles of mathematics, science, and engineering fundamentals. Use creativity to develop more innovative solutions.	6
CO 3	PO 5	Demonstarte lists,tuples and dictionaries With the usage of modern tools	1
CO 3	PSO 1	Summarize indexing mechanisms to design and develop efficient real-time computational problems.	3
CO 3	PSO 3	Infer sufficient knowledge of container data types and apply it in real-time for building successful career and doing higher studies.	3
CO 4	PO 1	Demonstrate different modules/packages in Python while developing solutions using the fundamentals of mathematics, science, and engineering.	3
CO 4	PO 3	Understand the usage of modules/packages while developing solutions for complex engineering problems and design system using principles of mathematics, science, and engineering fundamentals. Use creativity to develop more innovative solutions.	8
CO 4	PO 5	Interpret different string functions by using modern tools	1
CO 4	PO 10	Extend the focus to understand the usage of modules/packages and communicate effectively with the Engineering community and with society at large.	3
CO 4	PO 12	Summarize string handling functions to implement in project management	7
CO 4	PSO 1	Demonsrtate different modules to understand, design and analyze computer programs in reducing time and space complexities of various applications.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 4	PSO 3	Illustrate modern computer tools in implementing string handling mechanisms for various applications to become a successful professional in the domains.	3
CO 5	P0 1	Make use of parameter passing and different types of arguments in user-defined functions to design efficiently modular programs by applying the knowledge of mathematics, science, Engineering fundamentals.	3
CO 5	P0 2	Apply modular programming concepts for problem identification,formulation and data collection .	8
CO 5	PO 3	Select strong foundation of writing efficient modular programs using parameter passing mechanisms for career building by understanding the requirements and communicating effectively with engineering community.	7
CO 5	PO 5	Develop different functions by using modern tools	1
CO 5	PSO 1	Develop design and analyse python programming in the areas of concept of passing of parameters and arguments in functions to do modular programming.	3
CO 6	PO 1	Apply scientific principles and methodologies, Mathematical principles and other engineering disciplines for the procedural and object-oriented programming concepts used in Python.	3
CO 6	PO 2	Apply object oriented concepts in problem indentification,statement and validation .	7
CO 6	PO 3	Identify the need of object-oriented concepts while developing solutions for complex engineering problems and design system using principles of mathematics, science, and engineering fundamentals. Use creativity to develop more innovative solutions..	7
CO 6	PO 5	Develop object oriented principles using modern tools	1
CO 6	PO 10	Apply the knowledge of Python programming to communicate effectively with the Engineering community and society at large.	3
CO 6	PO 12	Identify the need of object oriented principles for preparation ad ability to engage in independent and lifelong learning	6
CO 6	PSO 1	Focus on writing programs using procedural and object oriented concepts for applications such as computational geometry, machine learning, Big data and AI by understanding and applying the engineering principles learning	3
CO 6	PSO 3	Acquire sufficient knowledge of object-oriented concepts and apply it in real-time for building successful career and doing higher studies.	3

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	10	10	11	1	5	3	3	12	5	12	12	1	3	2
CO 1	100	0.0	0.0	0.0	100	0.0	0.0	0.0	0.0	60	0.0	0.0	100	0.0	0.0
CO 2	100	50	80	0.0	100	0.0	0.0	0.0	0.0	60	0.0	0.0	100	0.0	100
CO 3	100	0.0	60	0.0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0.0	100
CO 4	100	50	80	0.0	100	0.0	0.0	0.0	0.0	60	0.0	88	100	0.0	100
CO 5	100	80	70	0.0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0.0	0.0
CO 6	100	80	70	0.0	100	0.0	0.0	0.0	0.0	60	0.0	75	100	0.0	100

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 $< C \leq 40\%$ – Low/ Slight

2 - 40 % $< C < 60\%$ –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	3	-	-	-	-	3	-	-	3	-	-
CO 2	3	2	3	-	3	-	-	-	-	3	-	-	3	-	3
CO 3	3	-	3	-	3	-	-	-	-	-	-	-	3	-	3
CO 4	3	-	3	-	3	-	-	-	-	3	-	3	3	-	3
CO 5	3	2	3	-	3	-	-	-	-	-	-	-	3	-	-
CO 6	3	3	3	-	3	-	-	-	-	3	-	3	3	-	3
TOTAL	18	7	15	-	18	-	-	-	-	12	-	6	18	-	12
AVERAGE	3.0	2.3	3	-	3.0	-	-	-	-	3.0	-	3.0	3.0	-	3.0

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	case studies	-
Assignments	-	Open ended experiments	✓		

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**Introduction to Python**
	Introduction to Python: Features of Python, History and Future of Python, Working with Python – interactive and script mode, Identifiers and Keywords, Comments, Indentation and Multi-lining, Data types – built-in data types, Operators and Expressions, Console Input/Output, Formatted printing,Built-in Functions, Library Functions.
MODULE II	**DECISION CONTROL STATEMENTS**
	Selection/Conditional Branching Statements: if, if-else, nested if, if-elif-else statement(s), Basic Loop Structures/ Iterative Statements – while and for loop, Nested loops, break and continue statement, pass Statement, else Statement used with loops..
MODULE III	**CONTAINER DATA TYPES**
	Lists: Accessing List elements, List operations, List methods, List comprehension; Tuples: Accessing Tuple elements, Tuple operations, Tuple methods, Tuple comprehension, Conversion of List comprehension to Tuple, Iterators and Iterables, zip() function. Sets: Accessing Set elements, Set operations, Set functions, Set comprehension;Dictionaries: Accessing Dictionary elements, Dictionary operations, Dictionary Functions, Nested Dictionary, Dictionary comprehension.s.
MODULE IV	**STRINGS AND FUNCTIONS**
	Strings: Accessing string elements, string properties, string operations. Functions: Communicating with functions, Variable Scope and lifetime, return statement, Types of arguments, Lambda functions, Recursive functions..
MODULE V	**CLASSES AND OBJECTS**
	Classes and Objects – Defining Classes, Creating Objects, Data Abstraction and Hiding through Classes, Class Method and self Argument, Class variables and Object variables, init() and de () method, Public and private data members, Built-in Class Attributes, Garbage Collection. OOPs Features:Abstraction, Encapsulation, Inheritance, and Polymorphism.

TEXTBOOKS:

1. Reema Thareja, "Python Programming - Using Problem Solving Approach", Oxford Press, 1st Edition, 2017.
2. Dusty Philips, "Python 3 Object Oriented Programming", PACKT Publishing, 2nd Edition,2015.

REFERENCE BOOKS:

1. Yashavant Kanetkar, Aditya Kanetkar, "Let Us Python", BPB Publications, 2nd Edition, 2019.
2. Martin C. Brown, "Python: The Complete Reference", Mc. Graw Hill, Indian Edition, 2018.
3. Michael H. Goldwasser, David Letscher, "Object Oriented Programming in Python", Prentice Hall, 1st Edition, 2007.
4. Taneja Sheetal, Kumar Naveen, "Python Programming – A Modular Approach", Pearson, 1st Edition, 2017
5. Nageswar Rao, "Core Python Programming", Dreamtech Press, 2018.

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		
	Discussion on mapping COs with POs. (OBE)		
	CONTENT DELIVERY (THEORY)		
1-2	Introduction to Python: Features of Python, History and Future of Python	CO 1	T1:3.1 –3.3
3-4	Working with Python – interactive and script mode, Identifiers and Keywords, Comments, Indentation and Multi-lining, Databtypes – built-in data types	CO 1	T1:3.4-3.9
5-8	Operators and Expressions	CO 1	T1:3.12
9-10	Console Input/Output, Formatted printing, Built-in Functions, Library Functions	CO 1	T1:3.15
11-14	Control Statement(s)	CO 2	T1: 4.1 –4.8
15-17	Lists and Tuples	CO 3	T1:3.15
18-19	Conversion of List comprehension to Tuple, Iterators and Iterables, zip() function	CO 3	T1:3.15
20-21	Sets, Dictionaries:	CO 3	T1:3.15
22-23	Nested Dictionary, Dictionary comprehension	CO 3	T1:3.15
24-25	Strings: Accessing string elements, string properties, string operations	CO 4	T1: 6.1 –6.8
26-27	Functions: Communicating with functions, Variable Scope and lifetime, return statement	CO 5	T1:5.1 –5.5

28-29	Types of arguments, Lambda functions, Recursive functions	CO 5	T1:5.6 –5.8
30-31	Classes and Objects – Defining Classes, Creating Objects	CO 6	T1 : 9.1 – 9.3
32-33	Data Abstraction and Hiding through Classes, Class Method and self Argument	CO 6	T1: 9.2 – 9.4
34-36	Class variables and Object variables, init() and del () method	CO 6	T1:9.5 – 9.7
37-38	Public and private data members, Built-in Class Attributes, Garbage Collection	CO 6	T1:9.8 – 9.13
39-41	OOPs Features: Abstraction, Encapsulation, Inheritance, and Polymorphism	CO 6	T1:10.1-10.3
PROBLEM SOLVING/ CASE STUDIES			
1	Data Types	CO 1	T1:3.7.1-3.7.4
2	Operators and Expressions	CO 1	T1:3.12.1-3.12.10
3	Built-in Functions , Library functions	CO 1	T1:6.4-6.10
4	Conditional branching Statements	CO 2	T1:4.1-4.2
5	Iterative Statements	CO 2	T1:4.3-4.8
6	Lists	CO 3	T1:8.2-8.2.10
7	Tuples	CO 3	T1:8.4.1
8	Sets	CO 3	T1:8.5.1
9	Dictionaries	CO 3	T1:8.6.1-8.6.12
10	Strings	CO 4	T1:6.1-6.10
11	Functions	CO 5	T1:5.1:5.10
12	Classes and Objects	CO 6	T1:9.1-9.15
13	__init()__and __del__() method	CO 6	T1:9.4-9.6
14	Inheritance	CO 6	T1:10.1-10.4
15	Polymorphism	CO 6	T1:10.2.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Define bound and unbound variable.	CO 1	T1:9.1
2	Define a control structure?	CO 2	T1:4.1-4.8
3	How to slice lists in Python?	CO 3	T1:8.2-8.6
4	Write the syntax of defining a function?	CO 5	T1:5.1-5.2

5	List out the features of object oriented programming.	CO 6	T19.1-9.3
DISCUSSION OF QUESTION BANK			
1	Write the features and applications of Python programming language?	CO 1	T1:3.1-3.3
2	Write a program to calculate the roots of a quadratic equation?	CO 1	T1:3.5-3.7
3	Write a program to remove all duplicate elements from a list?	CO 3	T1:8.2-8.6
4	Write a program that accepts a string from user and redisplays the same string after removing vowels from it?	CO 4	T1:6.1-6.3
5	Write a program that has a class Person string name and date of birth (DOB) of a person. The program should subtract the DOB from today's date to find out whether a person is eligible for vote or not?	CO 6	T1:9.1-9.3

Course Coordinator
B Dilip Chakravarty

HOD CSE(CS)

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

Course Title	**ENGLISH LANGUAGE AND COMMUNICATION SKILLS LABORATORY**					
Course Code	AHSC04					
Program	B.Tech					
Semester	I	ME				
Course Type	Foundation					
Regulation	UG-20					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	-	-	-	2	1	
Course Coordinator	Dr. M.Sailaja, Associate Professor					

I COURSE OVERVIEW:

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

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
English Language and Communication Skills 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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Sofware based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

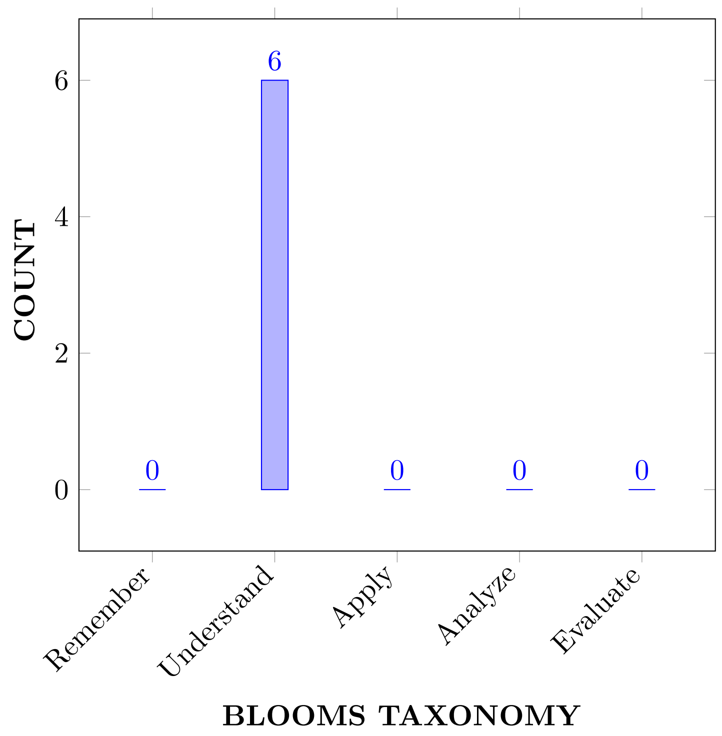
I	Facilitate computer-assisted multi-media instructions to make possible individualized and independent language learning.
II	The critical aspect of speaking and reading for interpreting in-depth meaning of the sentences.
III	Use language appropriately for social interactions such as public speaking,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

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	-	-
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	-	-
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	-	-

3 = High; 2 = Medium; 1 = Low

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

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

CO 4	PO 10	Choose suitable **grammatical** structures and **punctuation** marks at **speaking** and **writing** areas maintaining **clarity** at professional platform.	5
CO 5	PO 10	Interpret the **grammatical** knowledge and **punctuation** marks systematically towards providing the **clarity** in **speaking** and **writing**.	5
CO 6	PO 10	Demonstrate the role of **grammar** and **punctuation** marks understanding the meaning between the sentences as well as paragraphs in **speaking** or **writing** for a **clarity**.	5

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

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

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**INTRODUCTION ABOUT ELCS LAB..**
	Introducing Self and Introducing Others – feedback.
WEEK II	**INTRODUCTION TO PHONETICS AND PRACTICING CONSONANTS**
	Describing a person or place or a thing using relevant adjectives – feedback.
WEEK III	**PRACTICING VOWEL SOUNDS.**
	JAM Sessions using public address system.
WEEK IV	**STRUCTURE OF SYLLABLES.**
	Giving directions with help of using appropriate phrases – activities.
WEEK V	**WORD ACCENT AND STRESS SHIFTS. – PRACTICE EXERCISES.**
	Starting a conversation, developing and closing appropriately using fixed expressions..
WEEK VI	**PAST TENSE AND PLURAL MARKERS.**
	Role Play activities.
WEEK VII	**WEAK FORMS AND STRONG FORMS.**
	Oral Presentation..
WEEK VIII	**INTRODUCTION TO INTONATION- USES OF INTONATION - TYPES OF INTONATION- PRACTICE EXERCISES.**
	Expresions In Various Situations.
WEEK IX	**NEUTRALIZATION OF MOTHER TONGUE INFLUENCE (MTI).**
	Sharing Summaries Or Reviews On The Topics Of Students' Choice.
WEEK X	**COMMON ERRORS IN PRONUNCIATION AND PRONUNCIATION PRACTICE THROUGH TONGUE TWISTERS.**
	Interpretation Of Proverbs And Idioms.
WEEK XI	**LISENING COMPREHENSION.**
	Etiquettes.

WEEK XII	**TECHNIQUES AND METHODS TO WRITE SUMMARIES AND REVIEWS OF VIDEOS.**
	Writing Messages, Leaflets And Notices Etc.
WEEK XIII	**COMMON ERRORS.**
	Resume Writing.
WEEK XIV	**INTRODUCTION TO WORD DICTIONARY.**
	Group Discussions – Video Recording – Feedback.
WEEK XV	**INTRODUCTION TO CONVERSATION SKILLS.**
	Mock Interviews.

TEXTBOOKS

1. ENGLISH LANGUAGE AND COMMUNICATION SKILLS: LAB MANUAL

REFERENCE BOOKS:

1. . Meenakshi Raman, Sangeetha Sharma, "Technical Communication Principles and Practices", Oxford University Press, New Delhi, 3rd Edition, 2015.

2. Rhirdion, Daniel, "Technical Communication", Cengage Learning, New Delhi, 1st Edition, 2009.

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Introduction About Elcs Lab, Introducing Self And Introducing Others – Feedback.	CO 2	R1: 1.2
2	Introduction To Phonetics And Practicing Consonants, Describing A Person Or Place Or A Thing Using Relevant Adjectives – Feedback.	CO 2	R2: 25-30
3	Practicing Vowel Sounds,Jam Sessions Using Public Address System.	CO 2	R1: 28-29,49-54
4	Structure Of Syllables, Giving Directions With Help Of Using Appropriate Phrases – Activities.	CO 3	R1: 23-38
5	Word Accent And Stress Shifts. – Practice Exercises, Starting A Conversation, Developing And Closing Appropriately Using Fixed Expressions.	CO 3	R1: 2.4
6	Past Tense And Plural Markers,	CO 2	R3: 4.5
7	Weak Forms And Strong Forms,Oral Presentation.	CO 2	R3: 4.6
8	Introduction To Intonation- Uses Of Intonation - Types Of Intonation- Practice Exercises, Expresions In Various Situations.	CO 2	R2: 39-42
9	Neutralization Of Mother Tongue Influence (Mti), Sharing Summaries Or Reviews On The Topics Of Students' Choice.	CO 2	R2: 5.2
10	Common Errors In Pronunciation And Pronunciation Practice Through Tongue Twisters, Interpretation Of Proverbs And Idioms.	CO 2	R1:42-43
11	Lisening Comprehension, Etiquettes	CO 5	R1:44-48

12	Techniques And Methods To Write Summaries And Reviews Of Videos,Writing Messages, Leaflets And Notices Etc.	CO 4	R1:107-110
13	Common Errors, Resume Writing.	CO 4	R1:7.3
14	Introduction To Word Dictionary,Group Discussions – Video Recording – Feedback.	CO 5	R1:7.3
15	Introduction To Conversation Skills,Mock Interviews.	CO 6	R1: 54-58

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

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

Signature of Course Coordinator **HOD**
Dr. M.Sailaja, Associate Professor

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

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**PHYSICS LABORATORY**				
Course Code	AHSC05				
Program	B.Tech				
Semester	I	ME			
Course Type	FOUNDATION				
Regulation	IARE - UG 20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Mr. K Saibaba, Assistant Professor				

I COURSE OVERVIEW:

This lab course provides hands on experience in a number of experimental techniques and developscompetenceintheinstrumentationtypicallyusedinphysics.This also develops student's expertise in applying physical concepts to practical problem and in learning about experimental techniques with advanced equipments. This laboratory includes experiments involving electromagnetism and optoelectronics.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
-	-	-	Basic principles of physics	1.5

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing Further Experiments

V EVALUATION METHODOLOGY:

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

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

The emphasis on the experiments is broadly based on the following criteria 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.

A. Experiment Based

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

B. Programming Based

Purpose	**Algorithm**	**Program**	**Conclusion**	**Viva**	**Total**
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

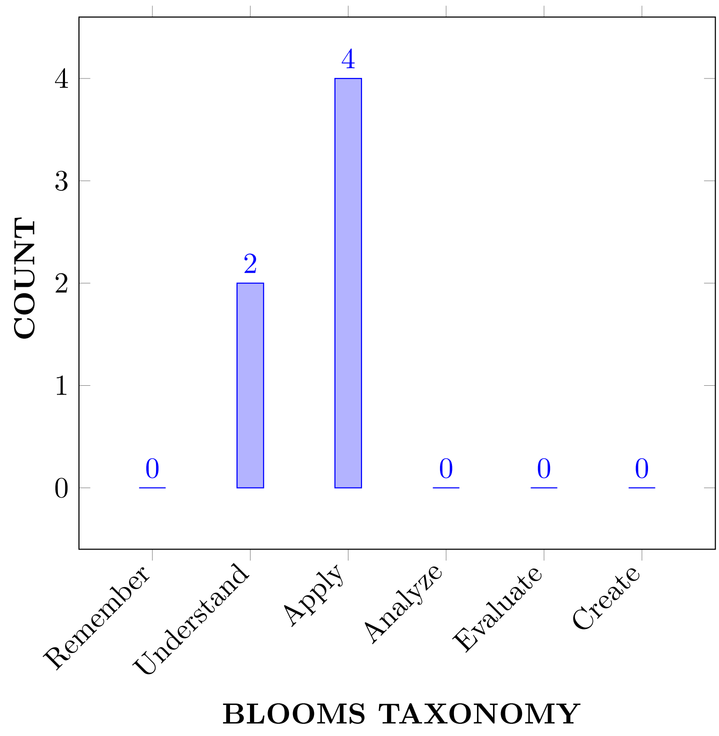
I	To familiarize with the lab facilities, equipment, standard operating procedures.
II	About the different kinds of functional electric and magnetic materials which paves a way for them to use in various technical and engineering applications.
III	The analytical techniques and graphical analysis to study the experimental data for optoelectronic devices.
IV	The applications of variation in the intensity of light due to natural phenomena like interference and diffraction.

VII COURSE OUTCOMES:

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

CO 1	**Identify** the type of semiconductor using the principle of Hall Effect and also determine the energy gap of a semiconductor diode.	Apply
CO 2	**Illustrate** principle, working and application of wave propagation and compare results with theoretical harmonics and overtones.	Understand
CO 3	**Investigate** the energy losses associated with a given Ferro magnetic material and also magnetic field induction produced at various points along the axis of current carrying coil.	Apply
CO 4	**Examine** launching of light through optical fiber from the concept of light gathering capacity of numerical aperture.	Understand
CO 5	**Utilize** ththe phenomena of interference and diffraction for the determination of various parameters like radius of curvature of convex lens, wavelength of laser light and width of single slit.	Apply
CO 6	**Investigate** V-I/L-I characteristics of various optoelectronic devices like Light Emitting Diode, Photodiode to understand their basic principle of functioning as well as to infer the value of Planck's constant.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies		

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	**Justification for mapping (Students will be able to)**	No. of Key Competencies
CO 1	PO 1	Identify basic principle of Hall effect and make use of mathematical expression for Hall coefficient to deduce the type of semiconductor.	2
	PO 2	Understand the given problem statement of identification of type of semiconductor and formulate Hall coefficient from experimental collection of information and data in reaching substantial conclusions by the interpretation of results.	4
	PO 1	Determine the energy gap of a semiconductor diode by making use of graphical analysis of current versus temperature curve.	2

CO 2	PO 1	Recall the theory of propagation of longitudinal and transverse waves and make use of number of loops formation in string to determine frequency of an electronically maintained tuning fork.	2
	PO 2	Understand the given problem statement of stationary wave propagation and formulate harmonics and overtones of fundamental frequency from experimental collection of information and data in reaching substantial conclusions by the interpretation of results.	4
CO 3	PO 1	Explain the variation of magnetic field at various points along the axis of current carrying coil and make use of mathematical expression of Tangent's law using Stewart Gee's apparatus.	2
	PO 2	Understand the given problem statement of current loop and formulate magnetic field induction at various points along the axis of current loop from experimental collection of information and data in reaching substantial conclusions by the interpretation of results.	4
	PO 1	Investigate the energy losses associated with a given ferromagnetic material and make use of graphical representation of hysteresis loop exhibited by magnetic material.	2
	PO 2	Understand the given problem statement of energy losses associated with a given ferromagnetic material and formulate hysteresis loop from experimental collection of information and data in reaching substantial conclusions by the interpretation of results.	4
	PO 4	Apply simulation tool to get hysteresis curve of a ferromagnetic material and understand energy losses associated with material.	1
	PSO 3	Make use of modern simulation tool to get information about energy losses associated with a ferromagnetic material.	1
CO 4	PO 1	Interpret launching of light through optical fiber and make use of mathematical expression for analyzing light gathering capacity through numerical aperture.	2
	PO 4	Make use of optical fiber trainer kit and understand conversion of electrical to light energy..	1
CO 5	PO 1	Explain the concept of interference in Newton's rings and make use of it to determine the radius of curvature of convex lens.	2
	PO 4	Make use of microscope to get Newton's rings and understand the phenomenon of interference in reflected light.	1
	PO 1	Recollect the phenomena of diffraction from N-slits and make use of it for the determination of wavelength of a given laser.	1

	PO 1	Understand the phenomenon of single slit diffraction and make use of it to determine the slit width by using laser light as monochromatic source.	1
CO 6	PO 1	Explain the V-I characteristics of light emitting diode and infer the value of planck's constant by plotting temperature versus current curve.	2
	PO 1	Understand the phenomenon of recombination of electron-hole pair and determine the value of threshold voltage of a given LED.	2
	PO 1	Illustrate the variation of photo current with light intensity in a photo diode.	1

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

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

3 = High; 2 = Medium; 1 = Low

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 1	**HAL LEFFECT (LORENTZFORCE)**
	Determination of charge carrier density.
WEEK 2	**MELDE'S EXPERIMENT**
	Determination of frequency of a given tuning fork
WEEK 3	**STEWART GEE'S APPARATUS**
	Magnetic field along the axis of current carrying coil – Stewart and Gee's method.
WEEK 4	**B-H CURVE WITH CRO**
	To determine the value of retentivity and coercivity of a given magnetic material.
WEEK 5	**ENERGY GAP OF A SEMICONDUCTOR DIODE**
	Determination of energy gap of a semiconductor diode.
WEEK 6	**PHOTO DIODE**
	Studying V-I characteristics of Photo Diode.
WEEK 7	**OPTICAL FIBER**
	Evaluation of numerical aperture of a given optical fiber.
WEEK 8	**WAVELENGTH OF LASER LIGHT**
	Determination of wavelength of a given laser light using diffraction grating.
WEEK 9	**PLANK'S CONSTANT**
	Determination of Plank's constant using LED.
WEEK 10	**LIGHT EMITTING DIODE**
	Studying V-I Characteristics of LED.
WEEK 11	**NEWTONS RINGS**
	Determination of radius of curvature of a given plano - convex lens.
WEEK 12	**SINGLE SLIT DIFFRACTION**
	Determination of width of a given single slit.

TEXTBOOKS

1. 1 CL Arora, "Practical Physics", S Chand and Co.,New Delhi, 3rd Edition,2012.

2. 2 Vijay Kumar, Dr. T. Radha krishna, "Practical Physics for Engineering Students", S M Enterprises, 2nd Edition, 2014.

REFERENCE BOOKS:

1. 1 CF Coombs,"Basic Electronic Instrument Handbook", McGraw - HillBookCo.,1972.

2. 2 CH Bernardand CD Epp, John Wiley and Sons, " Laboratory Experiments in College Physics" Inc.,NewYork,1995.

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	Determination of charge carrier density.	CO 1	T1:13.5
2	Determination of frequency of a given tuning fork.	CO 2	T1:13.5
3	Determination of Magnetic field along the axis of current carrying coil – Stewart and Gee's method.	CO 3, CO 4	TT1:14.7
4	Determination of the energy loss per unit volume of a given magnetic material per cycle by tracing the Hysteresis loop.	CO 3	T1:15.7
5	Determination of energy gap of a semiconductor diode.	CO 1	T1:16.8
6	Studying V-I Characteristics of Photo Diode.	CO 6	T1:16.9
7	Evaluation of numerical aperture of a given optical fiber.	CO 4	T1:17.9
8	Determination of wavelength of a given laser light using diffraction grating.	CO 5	T1:18.10
9	Determination of Plank's constant using LED.	CO 6	T1:19.10
10	Studying V-I characteristics of LED	CO 6	T1:19.9
11	Determination of radius of curvature of a given Plano-convex lens.	CO 5	T1:23.10
12	Determination of width of a given single slit.	CO 5	T1:23.10

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	To determine the wavelength of different colored light using white light source by Newton's ring method
2	To study the bending losses and transmission losses of an optical Fiber
3	To observe the dispersion of prism by using spectrometer.
4	Study the characteristics of Laser diode.
5	To illustrate the interference pattern produced from the air wedge.
6	To determine the voltage current characteristics of solar cell

Signature of Course Coordinator **HOD,ME**
Mr.K Saibaba, Assistant Professor

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

Mechanical Engineering

COURSE DESCRIPTION

Course Title	**PYTHON PROGRAMMING LABORATORY**				
Course Code	ACSC02				
Program	B.Tech				
Semester	I	IT			
Course Type	Core				
Regulation	IARE - UG22				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	1	-	-	2	2
Course Coordinator	Ms. K Laxminarayanamma, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-		-

II COURSE OVERVIEW:

This course introduces students to write computer programs. This course presents the principles of structured programming using the Python language, one of the most increasingly preferred languages for programming today. Because of its ease of use, it is ideal as a first programming language and runs on both the PC and Macintosh platforms. However, the knowledge gained in the course can be applied later to other languages such as C and Java.The course uses iPython Notebook to afford a more interactive experience. Topics include fundamentals of computer programming in Python, object-oriented programming and graphical user interfaces.

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	Acquire programming skills in core Python.
II	Acquire Object-oriented programming skills in Python.
III	Develop the skill of designing graphical-user interfaces (GUI) in Python.
IV	Develop the ability to write database applications in Python
V	Acquire Python programming skills to move into specific branches - Internet of Things (IoT), Data Science, Machine Learning (ML), Artificial Intelligence (AI) etc.

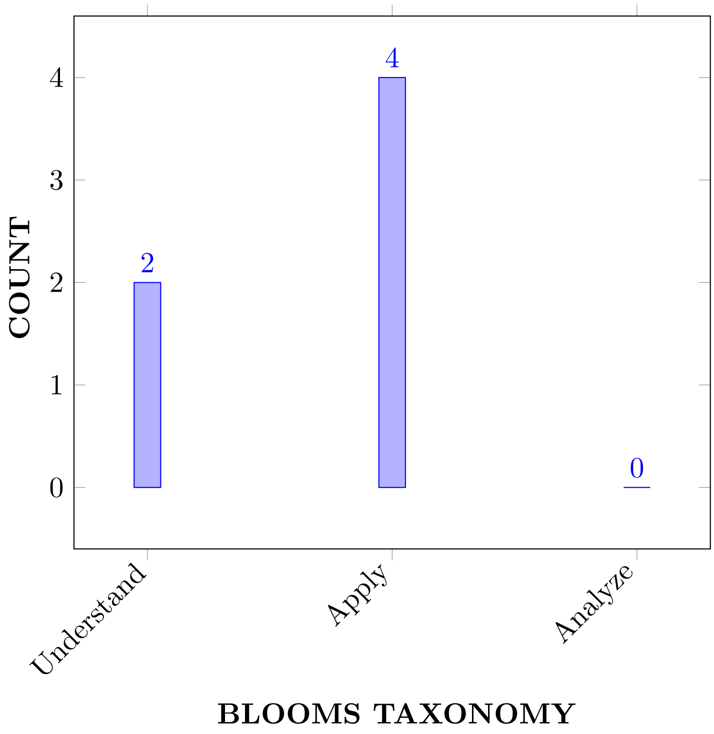
VII COURSE OUTCOMES:

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

CO 1	**Demonstrate** the basic concepts of python programming with the help of data types, operators and expressions, console input/output	Understand
CO 2	**Make use of** control statements for altering the sequential execution of programs in solving problems.	Apply

CO 3	**Demonstrate** operations on built-in container data types (list, tuple, set, dictionary) and strings.	Understand
CO 4	**Make use of** operations and applications on strings with the help of built in functions	Apply
CO 5	**Solve** the problems by using modular programming concepts through functions.	Apply
CO 6	**Identify** object-oriented programming constructs for developing large, modular and reusable real-time programs	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE / SEE/ Lab Exercises
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3	CIE / SEE/ Lab Exercises
PO 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	3	CIE / SEE/ Lab Exercises

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	-	-
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	-	-
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Demonstrate the data types of Python Programming by understating their importance and applicability (apply) in. **solving (complex) engineering problems by applying the principles of Mathematics and Engineering.**	3

	PO 2	Demonstrate the data types of Python Programming **with provided information and data in reaching substantiated conclusions by the interpretation of results.** .	3
	PO 5	Demonstrate the data types,operators,expressions and console I/O of Python Programming **for solving problems with the help of built in functions in Python programming**.	3
	PSO 3	Use datatypes,operators and expressions of Python Programming **in solving mathematical and statistical problems**	3
CO 2	PO 1	Illustrate the usage of control statements in solving real world problems **by applying principles of Mathematics, Science and Engineering.**	3
	PO 2	Illustrate the usage of control statements in solving real world problems **for visualizing the distribution of data in solving analysis problems.** .	2
	PO 5	Illustrate the usage of control statements along with built in functions of Python programming **for visualizing distribution of data with the help of built in function in Python programming language** .	3
	PSO 3	Use real time data to implement machine learning basics with Python programming **by analyzing the data and its relationships.** .	3
CO 3	PO 1	Illustrate the operations on built in container data types and strings **by applying the principles of Mathematics, Science and Engineering.** .	3
	PO 2	Illustrate the operations on built in container data types and strings in solving (complex) data centric engineering problems **from the provided information and substantiate with the interpretation of variations in the results.** .	3
	PSO 3	Implement the Python Programming basics **by exploring data analysis to solve complex problems.** .	3
CO 4	PO 1	Conclude the insights of data using exploratory data analysis **by applying the principles of Mathematics, Science and Engineering.**.	3
	PO 5	Define the list of operations on strings using built in functions **Find the different ways to model data and understand the limitations.**.	2
	PSO 3	Implement all string related operations using Python Programming **by exploring data limitations for generating predictions.** .	3
CO 5	PO 1	Apply the Modular Approach real world problems **by understanding the concepts of functions and code reusability**.	3

	PO 3	Understand the given problem statement and formulate (complex) engineering system **for developing a modular approach in solving problems that meet specified needs**.	2
	PO 5	Make use of functions **for creating the concept of code reusability**.	3
	PSO 3	Understand the concept of modularity by implementing different user defined and built functions **from real world problems to visualize the data to analyze the complexity.**.	3
CO 6	PO 1	Apply the knowledge of **engineering fundamentals**, and an **Mathematics and Engineering fundamentals principles to create a object oriented model on real time problems**.	3
	PO 3	Apply object oriented and modular concepts on **solving real world problems** reaching **and reusable conclusions**.	3
	PSO 3	Use built in functions in Python **for solving modular and reusable real time problems**.	3

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

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

XIII ASSESSMENT METHODOLOGY DIRECT:

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

XIV ASSESSMENT METHODOLOGY INDIRECT:

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

XV SYLLABUS:

WEEK 1	**OPERATORS**
	a.Read a list of numbers and write a program to check whether a particular element is present or not using membership operators. b. Read your name and age and write a program to display the year in which you will turn 100 years old c. Read radius and height of a cone and write a program to find the volume of a cone d.Write a program to compute distance between two points taking input from the user (Hint: use Pythagorean theorem)
WEEK 2	**CONTROL STRUCTURES**
	a. Read your email id and write a program to display the no of vowels, consonants, digits and white spaces in it using if…elif…else statement. b. Write a program to create and display a dictionary by storing the antonyms of words. Find the antonym of a particular word given by the user from the dictionary using while loop c. Write a Program to find the sum of a Series $1/1! + 2/2! + 3/3! + 4/4! +\ldots\ldots.+ n/n!$. (Input :n = 5, Output : 2.70833)
WEEK 3	**LIST**
	a. Read a list of numbers and print the numbers divisible by x but not by y (Assume x = 4 and y = 5). b. Read a list of numbers and print the sum of odd integers and even integers from the list.(Ex: [23, 10, 15, 14, 63], odd numbers sum = 101, even numbers sum = 24) c. Read a list of numbers and print numbers present in odd index position. (Ex: [10, 25, 30, 47, 56, 84, 96], The numbers in odd index position: 25 47 84) d. Read a list of numbers and remove the duplicate numbers from it. (Ex: Enter a list with duplicate elements: 10 20 40 10 50 30 20 10 80, The unique list is: [10, 20, 30, 40, 50, 80])
WEEK 4	**TUPLE**
	a. Given a list of tuples. Write a program to find tuples which have all elements divisible by K from a list of tuples. testlist = [(6, 24, 12), (60, 12, 6), (12, 18, 21)], K = 6, Output : [(6, 24, 12), (60, 12, 6)] b. Given a list of tuples. Write a program to filter all uppercase characters tuples from given list of tuples. (Input: testlist = [(”GFG”, ”IS”, ”BEST”), (”GFg”, ”AVERAGE”), (”GfG”,), (”Gfg”, ”CS”)], Output : [(”GFG”, ”IS”, ”BEST”)]). c. Given a tuple and a list as input, write a program to count the occurrences of all items of the list in the tuple. (Input : tuple = (’a’, ’a’, ’c’, ’b’, ’d’), list = [’a’, ’b’], Output : 3)

WEEK 5	**SET**
	a.Write a program to generate and print a dictionary that contains a number (between 1 and n) in the form (x, x*x). b.Write a program to perform union, intersection and difference using Set A and Set B. c.Write a program to count number of vowels using sets in given string (Input : "Hello World", Output: No. of vowels : 3) d.Write a program to form concatenated string by taking uncommon characters from two strings using set concept (Input : S1 = "aacdb", S2 = "gafd", Output : "cbgf").
WEEK 6	**DICTIONARY**
	a. Write a program to do the following operations: i. Create a empty dictionary with dict() method ii. Add elements one at a time iii. Update existing keys value iv. Access an element using a key and also get() method v. Deleting a key value using del() method b. Write a program to create a dictionary and apply the following methods: i. pop() method ii. popitem() method iii. clear() method c.Given a dictionary, write a program to find the sum of all items in the dictionary
WEEK 7	**STRINGS**
	a. Given a string, write a program to check if the string is symmetrical and palindrome or not. A string is said to be symmetrical if both the halves of the string are the same and a string is said to be a palindrome string if one half of the string is the reverse of the other half or if a string appears same when read forward or backward. b. Write a program to read a string and count the number of vowel letters and print all letters except 'e' and 's'. c. Write a program to read a line of text and remove the initial word from given text. (Hint: Use split() method, Input : India is my country. Output : is my country) d. Write a program to read a string and count how many times each letter appears. (Histogram)
WEEK 8	**USER DEFINED FUNCTIONS**
	a. A generator is a function that produces a sequence of results instead of a single value. Write a generator function for Fibonacci numbers up to n. b.Write a function mergedict(dict1, dict2) to merge two Python dictionaries. c.Write a fact() function to compute the factorial of a given positive number. d.Given a list of n elements, write a linearsearch() function to search a given element x in a list.

WEEK 9	**BUILT-IN FUNCTIONS**
	a. Write a program to demonstrate the working of built-in statistical functions mean(), mode(), median() by importing statistics library b. Write a program to demonstrate the working of built-in trignometric functions sin(), cos(), tan(), hypot(), degrees(), radians() by importing math module c. Write a program to demonstrate the working of built-in Logarithmic and Power functions exp(), log(), log2(), log10(), pow() by importing math module.
WEEK 10	**CLASS AND OBJECTS**
	a.Write a program to create a BankAccount class. Your class should support the following methods for i) Deposit ii) Withdraw iii) GetBalanace iv) PinChange b.Create a SavingsAccount class that behaves just like a BankAccount, but also has an interest rate and a method that increases the balance by the appropriate amount of interest (Hint:use Inheritance). c.Write a program to create an employee class and store the employee name, id, age, and salary using the constructor. Display the employee details by invoking employeeinfo() method and also using dictionary dict. d.Access modifiers in Python are used to modify the default scope of variables. Write a program to demonstrate the 3 types of access modifiers: public, private and protected.
WEEK 11	**MISCELLANEOUS PROGRAMS**
	Write a program to find the maximum and minimum K elements in Tuple using slicing and sorted() method (Input: testtup = (3, 7, 1, 18, 9), k = 2, Output: (3, 1, 9, 18)) b. Write a program to find the size of a tuple using getsizeof() method from sys module and built-in sizeof() method c.Write a program to check if a substring is present in a given string or not d. Write a program to find the length of a string using various methods: i. Using len() method ii. Using for loop and in operator iii. Using while loop and slicing
WEEK 12	**ADDITIONAL PROGRAMS - FILE HANDLING**
	a. Write a program to read a filename from the user, open the file (say firstFile.txt) and then perform the following operations: i. Count the sentences in the file. ii. Count the words in the file. iii. Count the characters in the file. b. Create a new file (Hello.txt) and copy the text to other file called target.txt. The target.txt file should store only lower case alphabets and display the number of lines copied c.Write a Python program to store N student's records containing name, roll number and branch. Print the given branch student's details only.

TEXTBOOKS

1. Michael H Goldwasser, David Letscher, "Object Oriented Programming in Python", Prentice Hall, 1st Edition, 2007.

2. Yashavant Kanetkar, Aditya Kanetkar, "Let us Python", BPB publication, 1st Edition, 2019
3. Ashok Kamthane, Amit Kamthane, "Programming and Problem Solving with Python", McGraw Hill Education (India) Private Limited, 2018.
4. Taneja Sheetal, Kumar Naveen, "Python Programming – A modular approach", Pearson, 2017

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1. www.oikostat.ch.
2. https://realpython.com/python3-object-oriented-programming//
3. https://python.swaroopch.com/oop.html#syllabus.
4. https://python-textbok.readthedocs.io/en/1.0/ObjectOrientedProgramming.html/

XVI COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Operators	CO 1	R1: 1
2	Control structures	CO 1	R3: 2
3	List	CO 2	R1: 7
4	Tuple	CO 2	R1: 8
5	Set	CO 3	R1: 2.4
6	Dictionary	CO 3	R1: 9
7	Strings	CO 4	R1: 10
8	User Defined Functions	CO 4	R3: 15
9	Built in Functions	CO 5	R1: 9
10	Class and Objects	CO5	R1: 10
11	Miscelaneous Programs	CO 6	R4:7
12	Additionaal programs - File Handling	CO 6	R4:10

XVII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Python program to Right rotate a numpy array to n.
2	Python program to multiply all elements in a Dictionary.
3	Python Program to put positive and negative numbers in a seperate list.
4	Python program to remove given key from a Dictionary.

Signature of Course Coordinator **HOD, ME**
Ms. K Laxcinarayanamma, Assistant Professor

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

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**CHEMISTRY**				
Course Code	AHSC06				
Program	B.Tech				
Semester	II	Mechanical			
Course Type	FOUNDATION				
Regulation	IARE - UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	-	2	-	-
Course Coordinator	Dr V N S R Venkateswararao, Associate Professor				

I COURSE PRE-REQUISITES:

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

II COURSE OVERVIEW:

The course discusses elements and compounds and their applied industrial applications. It deals with topics such as batteries, corrosion and control of metallic materials, water and its treatment for different purposes, engineering materials such as plastics, elastomers and biodegradable polymers, their preparation, properties and applications, energy sources and environmental science. Sustainable chemistry that focuses on the design of the products and processes that minimize or eliminate the use and generation of hazardous substances is also included.

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

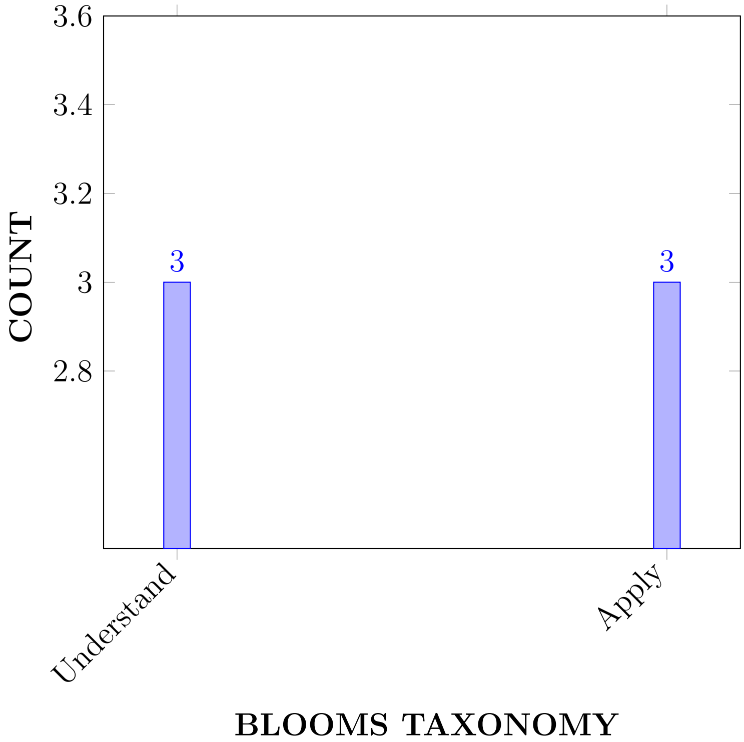
I	The concepts of electrochemical principles and causes of corrosion in the new development and breakthroughs efficiently in engineering and technology.
II	The different parameters to remove causes of hardness of water and their reactions towards the complexometric method.
III	The polymerization reactions with respect to mechanisms and its significance in industrial applications.
IV	The significance of green chemistry to reduce pollution in environment by using natural resources.

VII COURSE OUTCOMES:

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

CO 1	**Explain** the electrochemical principles, corrosion process in metals for protection of different metals from corrosion	Understand
CO 2	**Utilize** electrochemical cell parameters, electrochemical active surface area, current and over potential under given condition for calculating the electromotive force and electrode potential.	Apply
CO 3	**Identify** the hardness of water by different treatment methods for finding the hardness causing salts in water.	Apply
CO 4	**Compare** different types of polymerization reactions, mechanism of lubrication for utilizing in industries.	Understand
CO 5	**Make use** of green synthesis methods, different types of solid, liquid and gaseous fuels in terms of calorific value for utilizing in industries and automobiles.	Apply
CO 6	**Outline** the different types of natural resources and their applicability for understanding the effect of pollutants on air, water and soil that cause the environmental pollution.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining..	-	-
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	-	-
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	-	-

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes (COs)	POs / PSOs	Justification for mapping (Students will be able to)	No. of key competencies
CO 1	PO 1	**Explain** the operation of electrochemical systems in batteries, corrosion process in metals for protecting the metals from corrosion by using **principles of** science for solving **engineering problems**.	2
CO 2	PO 1	**Choose** different electrodes for finding pH of unknown solutions by applying **mathematical** expressions of cell potential by using **principles of science** and mathematics for solving **engineering** problems	3

	PO 2	**Identify** the problem **formulation and abstraction** for calculating electrode potential under non standard conditions by applying Nernst equation from the provided **information.**	2
CO 3	PO 1	**Explain** different treatment methods to produce soft water from raw water for solving **engineering problems** by applying the **principles of science.**	2
	PO 2	**Identify** the problem and formulate for finding the hardness of water in terms of CaCO3 equivalents with given **information and data** by applying **principles of science.**	2
CO 4	PO 1	**Illustrate** different types of polymerization reactions for synthesizing polymers from monomers, different types of lubricants to reduce friction in machines working under various temperature conditions by using **principles of science** for solving **engineering** problems	2
CO 5	PO 1	**Explain** the importance of green synthesis to minimize the generation of hazardous substances, different types of solid, liquid and gaseous fuels with their characteristics and calorific value by applying **mathematical** expressions for finding calorific value using **principles of science** and mathematics for solving engineering problems.	3
	PO 2	**Identify the given problem** and **formulate** for finding the calorific value of fuel with the given **information and data** by applying principles of science.	2
	PO 7	Make use of gaseous fuels like LPG, CNG to reduce the pollutants in atmosphere and know the impact in **socio economic and environmental** contexts for sustainable development.	2
CO 6	PO 1	**Explain** the concept of **living** and non living resources and the utility of these resources, effect of pollutants on air, water and soil that causes the environmental pollution for solving engineering problems by applying the **principles of science**	2
	PO 7	**Make use** of renewable and non renewable resources, control measures for air pollution, water pollution, soil pollution and noise pollution in **socio economic** an **environmental** contexts for sustainable development.	2

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

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

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

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

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

2 - 40 % $< C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

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

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

XVI ASSESSMENT METHODOLOGY DIRECT:

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

XVII ASSESSMENT METHODOLOGY INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**ELECTROCHEMISTRY AND BATTERIES**
	Electro chemical cells: Electrode potential, standard electrode potential, Calomel electrode and Nernstequation; Electrochemical series and its applications; Numerical problems; Batteries: Primary (Dry cell) and secondary batteries (Lead-acid storage battery, Li-ion battery). Corrosion: Causes and effects of corrosion: Theories of chemical and electrochemical corrosion, mechanism of electrochemical corrosion; Corrosion control methods: Cathodic protection, sacrificial anode and impressed current Cathodic protection; Surface coatings: Metallic coatings- Methods of coating- Hot dipping- galvanization and tinning, electroplating
MODULE II	**WATER TECHNOLOGY**
	Introduction: Hardness of water, causes of hardness; types of hardness: temporary and permanent hardness, expression and units of hardness; estimation of hardness of water by complexometric method; potable water and its specifications, Steps involved in the treatment of water, disinfection of water by chlorination and ozonization; External treatment of water; Ion-exchange process; Desalination of water: Reverse osmosis, numerical problems
MODULE III	**ENGINEERING MATERIALS**
	Polymers-classification with examples, polymerization-addition, condensation and co-polymerization; Plastics: Thermoplastics and thermosetting plastics; Compounding of plastics; Preparation, properties and applications of polyvinyl chloride, Teflon, Bakelite and Nylon-6, 6; Biodegradable polymers. Elastomers: Natural rubber, processing of natural rubber, vulcanization; Buna-s and Thiokol rubber; Lubricants: characteristics of lubricants, mechanism of lubrication – thick film, thin film, extreme pressure lubrication, properties – flash and fire point, cloud and pour point, viscosity and oiliness of lubricants.

MODULE IV	**GREEN CHEMISTRY AND FUELS**
	Introduction: Definition of green chemistry, methods of green synthesis: aqueous phase, microwave method, phase transfer catalyst and ultra sound method. Fuels: definition, classification of fuels ; Solid fuels: coal; analysis of coal: proximate and ultimate analysis; Liquid fuels: Petroleum and its refining; Gaseous fuels: Composition, characteristics and applications of LPG and CNG; Calorific value: Gross Calorific value(GCV) and Net Calorific value(NCV), numerical problems.
MODULE V	**NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION**
	Natural resources: Classification of resources, living and nonliving resources; Water resources: Use and over utilization of surface and ground water, floods and droughts, dams, benefits and problems; Land resources; Energy resources: renewable and non-renewable energy sources, use of alternate energy source. Environmental pollution: Causes, effects and control measures of air pollution, water pollution, soil pollution and noise pollution.

TEXTBOOKS

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2. Shashi Chawla, "Engineering Chemistry", Dhanat Rai and Company, 2011, 1st Edition.

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4. Anubha Kaushik, C.P.Kaushik, "Environmental Studies" New Age International publishers, 4th Edition, 2015.

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1. 1. Dr.Bharathi Kumari, "A text book of Engineering Chemistry", VGS Book Links, 8th Edition,2016.

2. 2. B. Siva Shankar, "Engineering Chemistry", Tata McGraw Hill Publishing Limited, 3rd Edition, 2015.

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

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	W1
CONTENT DELIVERY (THEORY)			
1	Outcome Based Education.		

2	Recall the concept of electro chemical cells.	CO 1	T1:6.1,R1: 2.6
3	Explain the electrode potential, standard electrode potential, electrochemical series and its applications.	CO 2	T1:6.2,R1: 2.9
4	Derive Nernst equation , numerical problems on cell potential.	CO 2	T1:6.5,R1: 2.6.3
5	Demonstate about calomel electrode. Batteries: primary (dry cell).	CO 1	T1: 6.7, R1:2.12
6	Explain the secondary batteries (Lead-acid storage battery), Li-ion battery.	CO 1	T1:6.12,R1: 2.12
7	Recognize the causes and effects of corrosion, chemical corrosion.	CO 1	T1:7.1, R1:2.14
8	Explain the electrochemical corrosion, mechanism of electrochemical corrosion.	CO 1	T1:7.2, R1:2.17
9	Explain about cathodic protection, sacrificial anode and impressed current.	CO 1	T1:7.14, R1:2.20
10	Apply metallic coatings, methods of coatings, hot dipping, galvanizing , tinning and electroplating.	CO 1	T1:7.14,R1: 2.22
11	Recall the hardness of water, causes of hardness.	CO 3	T1:1.3,R1: 1.4
12	Explain the types of hardness, temporary and permanent, units of hardness.	CO 3	T1:1.3,1.5,
13	Estimation of hardness of water by complexometric method,	CO 3	T1:1.5,R1: 1.6.2
14	Estimation of hardness of water by complexometric method.	CO 3	T1:1.14,R1: 1.6.4
15	Define potable water and its specifications, steps involved in treatment of water, disinfection of water by chlorination and ozonization.	CO 3	T1:1.12,R1: 1.6.5
16	Explain about external treatment of water; ion-exchange process.	CO 3	T1:1.11, R1:1.8.1
17	Explain about desalination of water: reverse osmosis.	CO 3	T1:1.13, R1:1.10
18	Recall polymers-classification with examples and Explain about the polymerization-addition, condensation and co- polymerization	CO 4	T1: 3.5,R1: 3.1
19	Explain the concept of compounding of plastics.	CO 4	T1:1.4, R1: 3.1.4
20	Expalin the preparation, properties and applications of polyvinyl chloride, teflon.	CO 4	T1:3.5,R1: 3.2
21	Explain the bakelite and nylon-6, 6.	CO 4	T1: 3.12,R1: 3.2.2
22	Define biodegradable polymers, synthetic biodegradable polymers.	CO 4	T1:3.14,R1: 3.2.3
23	Explain rubbers, natural rubber its process and vulcanization, Buna-s and thiokol rubber.	CO 4	T1: 3.15, R1:3.2.3
24	Elastomers: Synthetic rubbers,Buna-s and thiokol rubber.	CO 4	T1: 3.22, R1:3,3.4

25	Lubricants: characteristics of lubricants, mechanism of lubrication – thick film, thin film, extreme pressure lubrication.	CO 4	T1: 3.24,R1: 3.5
26	Properties–flash and fire point, cloud and pour point, viscosity and oiliness of lubricants.	CO 4	T1: 3.25,R1: 3.7
27	Definition and importance of green chemistry, methods of green synthesis: aqueous phase method.	CO 5	T5:6.8, T2:1.1
28	Explain the microwave method and phase transfer catalyst.	CO 5	T5: 6.8.3,T2: 8.1
29	Explain the ultra sound method.	CO 5	T5: 6.8.3, T2:9.2
30	Define fuels, classification of fuels and characteristics of a good fuels.	CO 5	T1:4.2, R1:6.2.1
31	Explain solid fuels, coal, Analysis of coal, proximate and ultimate analysis.	CO 5	T1:4.4.1, R1:7.1
32	Explain liquid fuels, petroleum and its refining.	CO 5	T1:4.5.2, R1:15.2
33	Explain the gaseous fuels, Composition, characteristics and applications of LPG and CNG.	CO 5	T1:4.6, R1:9.2
34	Apply the concept of calorific value, gross calorific value (GCV) and Net calorific value(NCV) to find calorific value of fuel, numerical problems.	CO 5	T1:4.8, R1:5.2
35	Recall natural resources: classification of resources, living and nonliving resources.	CO 6	T4:2.1
36	Explain the water resources: use and over utilization of surface and ground water, floods and droughts, Dams, benefits and problems.	CO 6	T4:2.2
37	Define energy resources, renewable and non-renewable energy sources.	CO 6	T4:2.3
38	Explain the alternate energy sources, land resources	CO 6	T4:2.5,5.2
39	Define environmental pollution, causes, effects and control of air pollution.	CO 6	T4: 4.2
40	Explain the causes, effects and control of water pollution.	CO 6	T4: 4.6
41	Explain the causes, effects and control of soil pollution and noise pollution.	CO 6	T4:4.12
PROBLEM SOLVING/ CASE STUDIES			
42	Problems on EMF of voltaic cell	CO 2	T1:6.2,R1: 2.9
43	Problems on EMF of a cell	CO 2	T1:6.5,R1: 2.6.3
44	Problems on electrode potential of the half cell by using Nernst equation	CO 2	T1:6.2,R1: 2.9
45	Problems on electrode potential of EMF of the cell by using Nernst equation.	CO 2	T1:6.5,R1: 2.6.3
46	Problems on temporary and permanent hardness in Degree French.	CO 3	T1:1.5, R1: 1.6.2
47	Problems on temporary, permanent and total hardness in ppm	CO 3	T1:1.14,R1: 1.6.4
48	Problems on the temporary, permanent and total hardness of water in Degree Clark.	CO 3	T1:1.5,R1: 1.6.2

49	Problems on the temporary, permanent and total hardness of water in Mg/L.	CO 3	T1:1.14,R1: 1.6.4
50	Problems on the total hardness in terms of calcium carbonate equivalents by using EDTA method.	CO 3	T1:1.5,R1: 1.6.2
51	Problems on the permanent hardness in terms of calcium carbonate equivalents by using EDTA method.	CO 3	T1:1.14,R1: 1.6.4
52	Problems on the temporary hardness in terms of calcium carbonate equivalents by using EDTA method.	CO 3	T1:1.5,R1: 1.6.2
53	Problems on the higher and lower calorific values of the fuel.	CO 5	T1:4.8, R1:5.2
54	Problems on the gross and net calorific values of the fuel.	CO 5	T1:4.8, R1:5.2
55	Problems on HCV and LCV	CO 5	T1:4.8, R1:5.2
56	Problems on GCV and NCV	CO 5	T1:4.8, R1:5.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Definitions & terminology discussion on electrochemistry and corrosion	CO 1	T1:1.3,R1: 1.4
58	Definitions & terminology discussion on water technology	CO 3	T1: 3.5,R1: 3.1
59	Definitions & terminology discussion on engineering	CO 4	T1: 3.5,R1: 3.1
60	Definitions & terminology discussion on green chemistry and fuels	CO 5	T1:4.2, R1:6.2.1
61	Definitions & terminology discussion on natural resources and environmental pollution	CO 1, CO 6	T4:2.1,2.8
DISCUSSION OF QUESTION BANK			
62	Question bank discussion on electrochemistry and Corrosion	CO 1	T1: 6.1, R1:2.12
63	Question bank discussion on water technology	CO 3	T1:1.3, R1: 1.4
64	Question bank discussion on engineering materials	CO 4	T1: 3.5,R1: 3.1
65	Question bank discussion on green chemistry and fuels	CO5	T1:4.2, R1:6.2.1
66	Question bank discussion on natural resources and environmental Pollution	CO 6	T4:2.1,2.8

Course Coordinator: **HOD, ME**
Dr V N S R Venkateswararao,Associate Professor

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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**MATHEMATICAL TRANSFORM TECHNIQUES**				
Course Code	AHSC07				
Program	B.Tech				
Semester	II				
Course Type	Foundation				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr.Satyanarayana G, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSC02	I	Linear Algebra and Calculus
B.Tech	-	-	-
B.Tech	-	-	-

II COURSE OVERVIEW:

This course focuses on transformations from theoretical based mathematical laws to its practical applications in the domain of various branches of engineering field. The course includes the transformations such as Laplace, Fourier, applications of scalar and vector field over surface, volume and multiple integrals. The course is designed to extract the mathematical developments, skills, from basic concepts to advance level of engineering problems to meet the technological challenges.

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

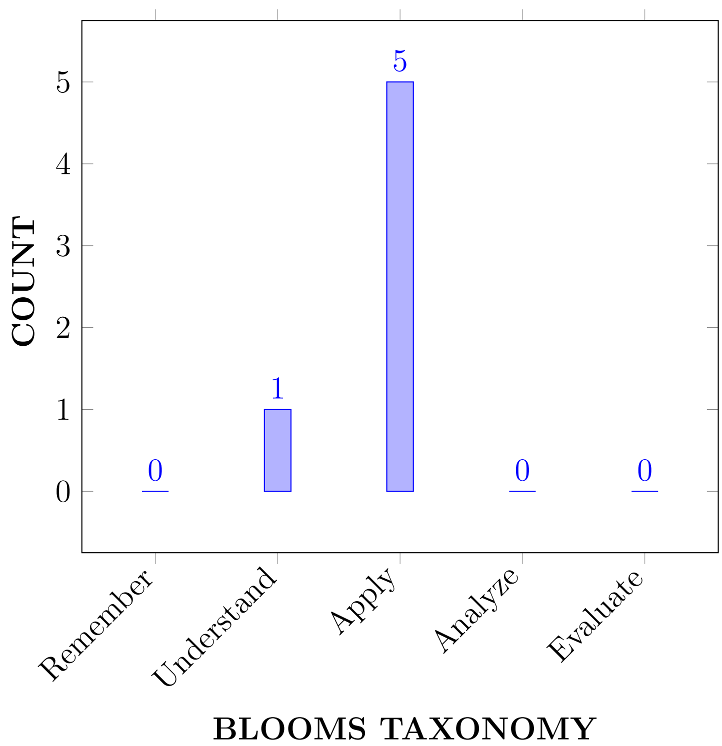
I	The transformation of ordinary differential equations in Laplace field and its applications
II	The operation of non-periodic functions by Fourier transforms.
III	The concepts of multiple integration for finding areas and volumes of physical quantities.
IV	The Integration of several functions by transforming the co-ordinate system in scalar and Vector fields.

VII COURSE OUTCOMES:

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

CO 1	**Explain** the properties of Laplace and inverse transform to various functions such as continuous, piecewise continuous, step, impulsive and complex variable functions.	Understand
CO 2	**Make use of** the integral transforms which converts operations of calculus to algebra in solving linear differential equations	Apply
CO 3	**Apply** the Fourier transform as a mathematical function that transforms a signal from the time domain to the frequency domain, non-periodic function up to infinity	Apply
CO 4	**Apply** the definite integral calculus to a function of two or more variables in calculating the area of solid bounded regions	Apply
CO 5	**Develop** the differential calculus which transforms vector functions, gradients. Divergence, curl, and integral theorems to different bounded regions in calculating areas.	Apply
CO 6	**Solve** Lagrange's linear equation related to dependent and independent variables the nonlinear partial differential equation by the method of Charpit concern to the engineering field	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	2	Seminar/ Conferences/ Research Papers
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	-	-
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	-	-

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Explain** the properties of Laplace and inverse transform to to **complex engineering problems** of various functions such as continuous, piecewise continuous, step, impulsive and complex variable functions with **principle of mathematics** .	2
CO2	PO 2	**Describe** the **formulation of** integral transforms (knowledge) which converts **complex engineering problems** using (apply) operations of calculus to algebra along with **basic principles of mathematics** reaching substantiated conclusions by the **interpretation of results** in solving linear differential equations	6
	PO4	**Explain** the integral transforms in solving ordinary differential equations will be **quantitatively measured** by using **MATLAB computer software**.	5
	PSO1	**Describe** the integral transforms concern Mechanical Engineering (apply) which converts operations of calculus to algebra in solving linear differential equations **in the design and implementation of complex systems.**.	2
CO3	PO 1	**Apply** the Fourier transform as a mathematical function that transforms a signal from the time domain to the **complex engineering problems** by the frequency domain, non-periodic function up to infinity with **Principle of Mathematics**	2
	PO2	**Apply** the Fourier transform as a **formulation** of mathematical function in **complex engineering problems** which transforms a non-periodic function using **principles of mathematics** to attain conclusions by the **interpretation of results**	6
	PSO1	**Identify** the properties of complex Fourier transform concern Mechanical Engineering which **intensifies (apply)** the boundary value problems in the **design and implementation** of complex systems.	2
CO4	PO2	**Apply** the **formulation** of definite integral calculus to a function of **complex engineering problems** of two or more variables using **principle of mathematics** in calculating the area of solid bounded regions by the **interpretation of results**.	6
CO5	PO2	**Develop** the **statement** and **formulation** differential calculus of **complex engineering problems** which transforms vector functions, gradients. Divergence, curl, and integral theorems using **principle of mathematics** to different bounded regions in calculating areas. by **interpretation of results**	6

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO6	PO1	**Solve** Lagrange's linear equation related to **complex engineering problems** such as dependent and independent variables the nonlinear partial differential equation by the method of Charpit concern to the engineering field **Principle of Mathematics**.	2
	PO2	**Describe** the **statement** and **formulation** of Lagrange's linear equation (understand) related to **complex engineering problems**, solutions are attained based on **principles of mathematics** to the **physical problems of engineering** by the **interpretation of results**.	6

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	-	60	-	45	-	-	-	-	-	-	-	-	100	-	-
CO 3	66.7	60	-	-		-	-	-	-	-	-		100	-	-
CO 4	-	60	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	60	-	-		-	-	-	-	-	-		-	-	-
CO 6	66.7	60	-	-	-	-	-	-	-	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**LAPLACE TRANSFORMS**
	Definition of Laplace transform, linearity property, piecewise continuous function, existence of Laplace transform, function of exponential order, first and second shifting theorems, change of scale property, Laplace transforms of derivatives and integrals, multiplied by t, divided by t, Laplace transform of periodic functions. Inverse Laplace transform: Definition of Inverse Laplace transform, linearity property, first and second shifting theorems, change of scale property, multiplied by s, divided by s; Convolution theorem and applications to ordinary differential equations.
MODULE II	**FOURIER TRANSFORMS**
	Fourier integral theorem, Fourier sine and cosine integrals; Fourier transforms; Fourier sine and cosine transform, properties, inverse transforms, finite Fourier transforms.
MODULE III	**MULTIPLE INTEGRALS**
	Double Integrals: Evaluation of double integrals in Cartesian coordinates and Polar coordinates; Change of order of integration; Area as a double integral; Transformation of coordinate system. Triple Integrals: Evaluation of triple integrals in Cartesian coordinates; volume of a region using triple integration.

MODULE IV	**VECTOR DIFFERENTIAL CALCULUS**
	Scalar and vector point functions; Definitions of Gradient, divergent and curl with examples; Solenoidal and irrigational vector point functions; Scalar potential function. Line integral, surface integral and volume integral, Green's theorem in a plane, Stoke's theorem and Gauss divergence theorem without proofs.
MODULE V	**PARTIAL DIFFERENTIAL EQUATIONS**
	Formation of partial differential equations by elimination of arbitrary constants and arbitrary functions, solutions of first order linear equations; Charpit's method;

TEXTBOOKS

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

REFERENCE BOOKS:

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

WEB REFERENCES:

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

COURSE WEB PAGE:

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
	OBE DISCUSSION		
1	Introduction to outcome based education		
	CONTENT DELIVERY (THEORY)		

2	Introduction to Laplace transform	CO1	T1:21.1 , 21.4 R1:5.1
3	First, second shifting theorems and change of scale property of Laplace transforms	CO1	T1:21.2 R1:5.1
4	Laplace transforms of Derivatives, Integrals, multiplication and Division by t to a function	CO1	T1:21.4 R1:5.1
5	Laplace transform of periodic functions	CO2	T1:21.7-21.10 R1:5.2-5.4
6	First, second shifting theorems and change of scale property of Inverse Laplace Transforms	CO1	T1:21.12 R1:5.1,5.6
7	Inverse Laplace transforms of Derivatives, Integrals, multiplication and Division by s to a function	CO2	T1:21.13 R1:5.1,5.3
8	Convolution theorem	CO2	T1:21.13 R1:5.4
9	Application of Laplace Transforms	CO2	T1:21.14 R1:5.5
10	Fourier integrals	CO3	T1:22.1-22.2 R1:10.8
11	Fourier transform	CO3	T1:22.3 R1:10.8
12	Fourier sine transform	CO3	T1:22.4 R1:10.9
13	Fourier Cosine Transforms	CO3	T1:22.5 R1:10.9
14	Properties of Fourier Transforms	CO3	T1:22.4 R1:10.9
15	Inverse Fourier Transform	CO3	T2:15.5 R1:7.5
16	Finite Fourier Transform	CO3	T2:16.5 R1:7.6
17	Infinite Fourier Transform	CO3	T2:16.5 R1:7.6
18	Double integrals in Cartesian form	CO4	T2:10.1 R1:16.1
19	Double integrals in Polar coordinates	CO4	T2:10.1 R1:16.2
20	Change of order of integration	CO4	T2:10.3 R1:16.4
21	Evaluation of Double Integrals for the Bounded Regions	CO4	T2:11.3 R1:16.5
22	Transformation of coordinates system	CO4	T2:11.3 R1:16.5
23	Triple integrals in Cartesian form	CO4	T2:11.3 R1:16.5

24	Volume of a region using triple integration	CO4	T2:11.3 R1:16.5
25	Problems on double and triple integrals	CO4	T2:11.3 R1:16.5
26	Scalar and Vector Point Function(Definitions of Gradient, divergent, curl and Scalar Potential function)	CO5	T2: 11.3 R1:16.11
27	Solenoidal and irrotational vectors	CO5	T1:17.1-17.2 R1:16.1-16.2
28	Line integral	CO5	T2: 11.3 R1:16.11
29	surface integral	CO5	T2: 11.3 R1:16.9
30	volume integral	CO5	T2: 11.4 R1:16.18
31	Green's theorem	CO5	T2: 11.3 R1:16.11
32	Stoke's theorem	CO5	T2: 11.3 R1:16.9
33	Gauss divergence theorem	CO5	T2: 11.4 R1:16.18
34	Elimination of arbitrary constants(Formation of PDE)	CO6	T1:17.1-17.2 R1:16.1-16.2
35	Elimination of arbitrary functions(Formation of PDE)	CO6	T1:17.5-17.6 R1:16.3.1
36	Non-Linear Partial differential equation of first order	CO6	T1:17.1-17.2 R1:16.1-16.2
37	Standard forms I, II ,III and IV	CO6	T1:17.1-17.2 R1:16.1-16.2
38	Non-Linear Partial differential equation of first order Standard forms V	CO6	T1:17.5-17.6 R1:16.3.1
39	Non-Linear Partial differential equation of first order Standard forms VI	CO6	T1:17.1-17.2 R1:16.1-16.2
40	Lagrange's Linear equation- Method of grouping	CO6	T1:17.5-17.6 R1:16.3.1

41	Lagrange's Linear Equation -Method of Multipliers	CO6	T1:17.1-17.2 R1:16.1-16.2
PROBLEM SOLVING/ CASE STUDIES			
42	Solving problems on Laplace Transform of First, second shifting theorems and change of scale property	CO 1	T1:21.1,21.4 R1:5.1
43	Solving problems on Inverse Laplace transforms of derivatives, integrals, multiplied by s, divided by s	CO 2	T1:21.13 R1:5.1,5.3
44	Solving problems on Convolution theorem	CO 2	T1:21.14 R1:5.5
45	Solving problems on Fourier sine and cosine integral	CO 3	T1:22.3 R1:10.8
46	Solving problems on finite Fourier transforms	CO 3	T1:22.4 R1:10.9
47	Solving problems on Evaluation of double integrals in Cartesian coordinates	CO 4	T2:10.1 R1:16.1
48	Solving problems on Transformation of coordinates system	CO 4	T2:10.1 R1:16.2
49	Solving problems on Evaluation of triple integrals in Cartesian coordinates	CO 4	T2:10.1 R1:16.2
50	Solving problems on Solenoidal and irrotational	CO 5	T2:11.3 R1:16.5
51	Solving problems on Green's theorem	CO 5	T2: 11.3 R1:16.11
52	Solving problems on Green's theorem	CO 5	T2: 11.3 R1:16.11
53	Solving problems on Stokes theorem	CO 5	T2: 11.3 R1:16.9
54	Gauss divergence theorem	CO 5	T2: 11.4 R1:16.18
55	Solving problems on formation of partial differential equations by elimination of arbitrary constants	CO 6	T1:17.1-17.2 R1:16.1-16.2
56	Solving problems on formation of partial differential equations by elimination of arbitrary functions	CO 6	T1:17.1-17.2 R1:16.1-16.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Definitions and terminology on Laplace transforms	CO 1,2	T1:21.1,21.4 R1:5.1
58	Definitions and terminology on Fourier transforms	CO 3	T1:22.1-22.2R1:10.8
59	Definitions and terminology on multiple integrals	CO 4	T2:15.5 R1:7.5
60	Definitions and terminology on vector calculus	CO 5	T2:10.3 R1:16.4

61	Definitions and terminology on partial differential equations.	CO 6	T1:17.1-17.2 R1:16.1-16.2
DISCUSSION OF QUESTION BANK			
62	Disscussion of Laplace transforms	CO 1,2	T1:21.1,21.4 R1:5.1
63	Disscussion of Fourier transforms	CO 3	T1:22.1-22.2 R1:10.8
64	Disscussion of multiple integrals	CO 4	T2:15.5 R1:7.5
65	Disscussion of vector calculus	CO 5	T2:10.3 R1:16.4
66	Disscussion of partial differential equations	CO 6	T1:17.1-17.2 R1:16.1-16.2

Signature of Course Coordinator **HOD,ME**

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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**					
Course Title	**ENGINEERING MECHANICS**					
Course Code	AMEC01					
Program	B. Tech					
Semester	TWO					
Course Type	Foundation					
Regulation	UG-20					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	3	-	3	-	-	
Course Coordinator	Dr. B D Y Sunil, Associate Professor					

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSC02	1	Linear Algebra and Calculus

II COURSE OVERVIEW:

Engineering Mechanics is a branch of Physics that deals with the study of the system of forces acting on a particle which is at rest or in motion. The course emphasizes thorough understanding of theories and principles related to static and dynamic equilibrium of rigid bodies to acquire the analytical capability required for solving engineering problems and is one of the foundation courses that forms the basis of many of the traditional branches of engineering such as aerospace, civil and mechanical engineering.

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Student's performance in the course shall be judged by taking into account the results of CIA and SEE together. Table-1 shows the typical distribution of weightage for CIA and 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 two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

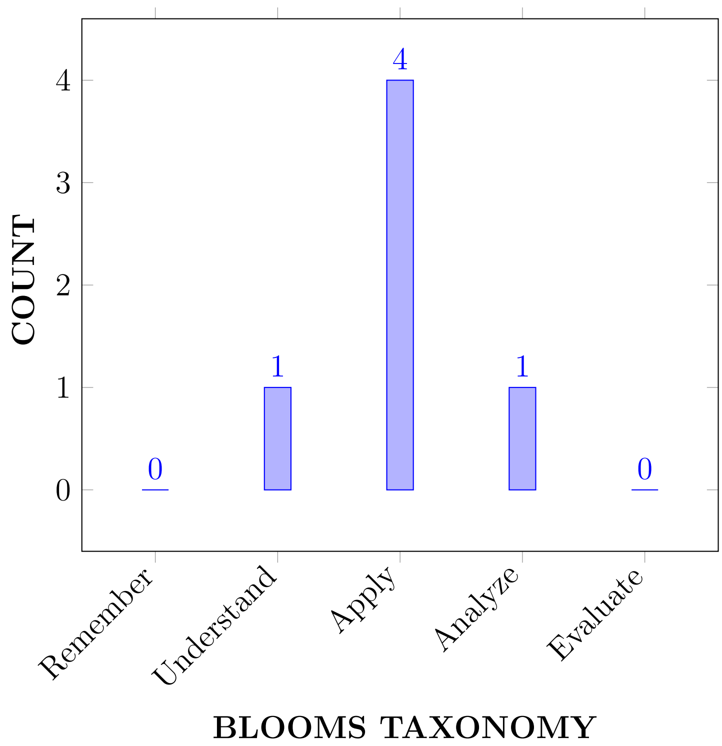
I	The application of mathematics and science principles to represent the free body diagrams in the area of rigid body mechanics.
II	The conditions of static and dynamic equilibrium of bodies subjected to a particular force system for solving the field problems.
III	The effects of force and motion while carrying out the innovative design functions of engineering.

VII COURSE OUTCOMES:

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

CO 1	**Identify** and unknown forces by free body diagrams to a given equilibrium force system through mechanics laws and derived laws.	Analyze
CO 2	**Interpret** the static and dynamic friction laws for the equilibrium state of a wedge, ladder and screw jack.	Understand
CO 3	**Identify** the centroid and centre of gravity for the simple and composite plane sections from the first principles.	Apply
CO 4	**Calculate** moment of inertia and mass moment of inertia of a circular plate, cylinder, cone and sphere from the first principles.	Apply
CO 5	**Apply** D'Alembert's principle to a dynamic equilibrium system by introducing the inertia force for knowing the acceleration and forces involved in the system.	Apply
CO 6	**Determine** the governing equation for momentum and vibrational phenomenon of mechanical system by using energy principles for obtaining co efficient and circular frequency.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	3	Research papers / Group discussion / Short term courses

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Apply the knowledge and principals of mathematics to engineering problems for determining reactions and resultants of forces using the knowledge of mathematics and science fundamentals	2
	PO 2	Analyze and formulate the engineering problems to determine the reactions and resultants of given force systems. Analyze and identify the problem statement, formulation and abstraction for the development of solution.	4
CO2	PO 2	Collect the data from complex engineering problems and implement them to draw the free body diagrams and interpret the results	3
CO 3	PO 2	Formulate the force system of friction problem and identify the appropriate equilibrium equation and develop the solution from the first principles of mathematics.	4
	PO 4	Understand the principles of engineering and apply them to the friction systems by analyzing the condition of motion of rest of the body	2
CO 4	PO 1	Apply the mathematical principles and engineering fundamentals to identify the centroid and centre of gravity in engineering problems.	2
CO 5	PO 1	Use the fundamentals of engineering and science in identifying the moment of inertia for regular and composite sections and solids.	2
CO 6	PO 2	Formulate the problem statement and model the system for getting the solution for the movement of bodies involving forces	3
	PO 4	Understand the technical concepts of D'Alembert's principle and interpret the equilibrium conditions for various applications.	2
	PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	2

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

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	40.0	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	-	30	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	40	-	18.2	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.7	-	-	-		-	-	-	-	-	-		-	-	-
CO 5	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	-	30.0	-	18.2		-	-	-	-	-	-		100	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	-	-	
CO 2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	-	1	-	1	-	-	-	-	-	-	-	-	3	-	-
TOTAL	9	4	-	2	-	-	-	-	-	-	-	-	3	-	-
AVERAGE	3.0	1.0	-	1.0	-	-	-	-	-	-	-	-	3.0	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO ENGINEERING MECHANICS**
	Classification of Engineering Mechanics, Basic Terminologies in Mechanics, Laws of Mechanics, Derived Laws, Characteristics of a Force, System of Forces, Composition of Forces, Resolution of Forces, Composition of Forces by Method of Resolution, Resultant of Non-Concurrent Force System, Supports and Reactions, Free Body Diagrams, Equilibrium of Bodies, Equilibrant, Equilibrium of Connected Bodies, Moment of a Force, Varignon's Theorem, Couple, Resolution of a Force into a Force and a Couple.
MODULE II	**FRICTION**
	Frictional Force, Laws of Friction, Angle of Friction, Angle of Repose and Cone of Friction, Types of friction, Limiting friction, Static and Dynamic Friction; Ladder friction, wedge friction, screw jack & differential screw jack.
MODULE III	**CENTROID, CENTRE OF GRAVITY AND MOMENT OF INERTIA**
	Centre of Gravity, Centroid, Difference between Centre of gravity and Centroid, Determination of Centroid of Simple Figures from First Principle, Centroid of Composite Sections, Centre of Gravity from First Principles, Centre of Gravity of Composite Bodies. Moment of Inertia, Polar Moment of Inertia, Radius of Gyration, Theorems of Moment of Inertia, Moment of Inertia from First Principle, Moment of Inertia of Standard Sections and Composite sections, Mass Moment of Inertia, Determination of Mass Moment of Inertia from First Principles, Parallel Axis Theorem/Transfer Formula, Mass Moment of Inertia of Composite Bodies.
MODULE IV	**PARTICLE DYNAMICS AND WORK ENERGY PRINCIPLE**
	Kinetics of Rigid Bodies – Newton's II law, D'Alembert's principle and its applications in plane motion and connected bodies. Work, Work Done by a Varying Force, Energy, Power, Work Energy Equation for Translation, Work Done by a Spring.
MODULE V	**IMPULSE MOMENTUM AND MECHANICAL VIBRATIONS**
	Linear Impulse and Momentum, Connected Bodies, Conservation of Momentum, Coefficient of restitution, Types of Impact. Vibrations - Basic terminology, free and forced vibrations, types of pendulum, Derivation for frequency and time period of simple, compound and torsion pendulums.

TEXTBOOKS

1. Irving H. Shames (2006), "Engineering Mechanics", Prentice Hall, 4th Edition,2013

2. S. Bhavikatti, "A Text Book of Engineering Mechanics", New Age International,1st Edition, 2012

3. R. C. Hibbler (2006), "Engineering Mechanics: Principles of Statics and Dynamics", Pearson Press.

REFERENCE BOOKS:

1. F. P. Beer and E. R. Johnston (2011), "Vector Mechanics for Engineers", Vol I - Statics, Vol II, – Dynamics, Tata McGraw Hill , 9th Edition,2013.
2. A.K.Tayal, "Engineering Mechanics", Uma Publications, 14th Edition, 2013.
3. R. K. Bansal "Engineering Mechanics", Laxmi Publication, 8thEdition, 2013.
4. Basudeb Bhattacharya, "Engineering Mechanics", Oxford University Press, 2nd Edition, 2014. item K.Vijay Reddy, J. Suresh Kumar, "Singer's Engineering Mechanics Statics and Dynamics", B S Publishers, 1st Edition, 2013.

WEB REFERENCES:

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

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=pages/mech-btech-course-syllabi-ug20

XIX COURSE PLAN:

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

OBE DISCUSSION			
1	Discussion on Objectives and Outcomes of the course Engineering Mechanics		
CONTENT DELIVERY (THEORY)			
1	Introduction to Engineering Mechanics, Classification and Laws of mechanics	CO 1	T2:5.5 R1:1.12.1
2	Force and force characteristics, System of forces	CO 1	T2:5.6 R1:1.12.3
3	Resultant, Resultant of coplanar concurrent force system	CO 1	T2:5.10 R1:1.15
4	Composition and resolution of forces, Composition of concurrent forces by method of resolution	CO 1	T2:5.15 R1:1.16
5	Free body diagram, Supports and reactions	CO 1	T2:5.17 R1:1.13.1
6	Equilibrium of bodies, Equilibrant	CO 1	T2:5.18 R1:1.13.2
7	Conditions of equilibrium	CO 1	T2:5.19 R1:1.13.3
8	Moment, Varignon's theorem, Couple	CO 1	T2:5.20 R1:1.7.1
9	Resolution of force into force and a couple	CO 1	T2:5.24 R1:1.17.3
10	Introduction to friction, Laws of friction, Important terms in friction, Types of friction	CO 2	T2:6.3 R1:2.6.1
11	Equilibrium of body on horizontal plane and rough inclined plane	CO 2	T2:6.5 R1:2.6.2
12	Effect of friction in connected bodies	CO 2	T2:5.5 R1:1.12.1
13	Friction in ladder applications	CO 2	T2:5.6 R1:1.12.3

14	Friction in wedge applications	CO 2	T2:5.10 R1:1.15
15	Screw jack, Efficiency of a screw jack and condition for maximum efficiency	CO 2	T2:5.15 R1:1.16
16	Over hauling and self-locking screws, differential screw jack	CO 2	T2:5.17 R1:1.13.1
17	Centre of gravity, Centroid, difference between centre of gravity and centroid	CO 3	T2:5.18 R1:1.13.2
18	Determination of centroid for simple sections	CO 3	T2:5.19 R1:1.13.3
19	Determination of centroid for composite sections	CO 3	T2:5.20 R1:1.7.1
20	Determination of centre of gravity of bodies, lines and arcs	CO 3	T2:5.24 R1:1.17.3
21	Moment of inertia, Radius of gyration, Polar moment of inertia, Theorems of moment of inertia	CO 4	T2:5.5 R1:1.12.1
22	Moment of inertia from first principles	CO 4	T2:5.6 R1:1.12.3
23	Moment of inertia of standard sections and composite sections	CO 4	T2:5.10 R1:1.15
24	Mass moment of inertia, Parallel axis theorem/transfer formula, Mass Moment of inertia of Composite Bodies	CO 4	T2:5.15 R1:1.16
25	Kinetics – introduction, Important terms, Newtons laws of motion, Relation between force and mass	CO 5	T2:5.17 R1:1.13.1
26	D'Alembert's principle and its application in plane motion	CO 5	T2:5.18 R1:1.13.2
27	Motion of lift, Motion of body on inclined plane, Problems	CO 5	T2:5.19 R1:1.13.3
28	D'Alembert's principle and its application for connected bodies	CO 5	T2:5.20 R1:1.7.1
29	Work, Energy and Power, Principles for problem solving using work energy method	CO 5	T2:5.24 R1:1.17.3
30	Work energy equation for translation	CO 5	T2:6.3 R1:2.6.1
31	Work done by spring	CO 5	T2:6.5 R1:2.6.2
32	Linear impulse and momentum, Conservation of momentum	CO 6	T2:5.5 R1:1.12.1
33	Impact of elastic bodies, Impact and types of impact	CO 6	T2:5.6 R1:1.12.3
34	Coefficient of restitution, Recoil of gun	CO 6	T2:5.10 R1:1.15
35	Introduction to vibrations, Free and forced vibrations, Simple harmonic motion and important terms	CO 6	T2:5.15 R1:1.16
36	Derivation for frequency and time period of simple pendulum	CO 6	T2:5.17 R1:1.13.1

37	Time period of simple pendulum when hanging from the ceiling of a lift, Gain or loss of oscillations due to change in 'g' and 'l' of simple pendulum	CO 6	T2:5.18 R1:1.13.2
38	Derivation for frequency and time period of compound pendulum	CO 6	T2:5.19 R1:1.13.3
39	Derivation for frequency and time period of torsional pendulum	CO 6	T2:5.20 R1:1.7.1
40	Oscillation of spring and arrangement of springs	CO 6	T2:5.24 R1:1.17.3
PROBLEM SOLVING/ CASE STUDIES			
1	Resultant of a force system	CO 1	T2:5.5 R1:1.12.1
2	Equilibrium of bodies	CO 1	T2:5.6 R1:1.12.3
3	Resultant by using Varignon's theorem	CO 1	T2:5.10 R1:1.15
4	Frictional force implementation	CO 2	T2:5.15 R1:1.16
5	Ladder friction	CO 2	T2:5.17 R1:1.13.1
6	Wedge friction	CO 2	T2:5.18 R1:1.13.2
7	Screw jack	CO 2	T2:5.19 R1:1.13.3
8	Centroid of simple and composite sections	CO 3	T2:5.20 R1:1.7.1
9	Centre of gravity of simple and composite bodies	CO 3	T2:5.24 R1:1.17.3
10	Moment of inertia and mass moment of inertia	CO 4	T2:6.3 R1:2.6.1
11	D'Alembert's principle for kinetic problems	CO 5	T2:6.5 R1:2.6.2
12	Work energy equation for translation in plane motion and connected bodies	CO 5	T2:5.5 R1:1.12.1
13	Impulse momentum for connected bodies	CO 6	T2:5.6 R1:1.12.3
14	Impact of elastic bodies	CO 6	T2:5.10 R1:1.15
15	Time period and frequency for various pendulums	CO 6	T2:5.15 R1:1.16
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Module – 1 – Introduction to Engineering Mechanics	CO 1	T2:5.5 R1:1.12.1
2	Module – 2– Friction	CO 2	T2:5.6 R1:1.12.3
3	Module – 3 – Centroid, Centre of Gravity and Moment of Inertia	CO 3, CO4	T2:5.10 R1:1.15

4	Module – 4 – Particle Dynamics and Work Energy Principle	CO 5	T2:5.15 R1:1.16
5	Module – 5 – Impulse Momentum and Mechanical Vibrations	CO 6	T2:5.17 R1:1.13.1
DISCUSSION OF QUESTION BANK			
1	Module – 1 – Introduction to Engineering Mechanics	CO 1	T2:5.5 R1:1.12.1
2	Module – 2 – Friction	CO 2	T2:5.6 R1:1.12.3
3	Module – 3 – Centroid, Centre of Gravity and Moment of Inertia	CO 3, CO4	T2:5.10 R1:1.15
4	Module – 4 – Particle Dynamics and Work Energy Principle	CO 5	T2:5.15 R1:1.16
5	Module – 5 – Impulse Momentum and Mechanical Vibrations	CO 6	T2:5.17 R1:1.13.1

Signature of Course Coordinator **HOD,ME**

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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**BASIC ELECTRICAL ENGINEERING**				
Course Code	AEEC01				
Program	B.Tech				
Semester	II	ME			
Course Type	Foundation				
Regulation	IARE - UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms.T Saritha Kumari, Assistant Professor,EEE				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSC02	I	-

II COURSE OVERVIEW:

The Basic Electrical Engineering enables knowledge on electrical quantities such as current, voltage, and power, energy to know the impact of technology in global and societal context. This course provides knowledge on basic DC and AC circuits used in electrical and electronic devices, highlights the importance of transformers, electrical machines in generation, transmission and distribution of electric power, identify the types of electrical machines suitable for particular applications.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Fluid Dynamics	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
17%	Remember
50%	Understand
33%	Apply
0 %	Analyze

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

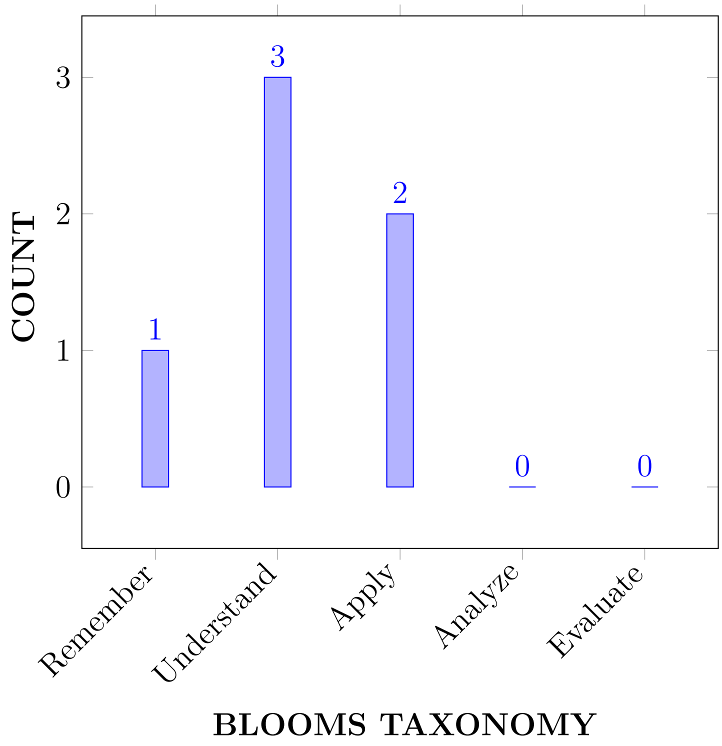
I	The fundamentals of electrical circuits and analysis of circuits with DC excitation using circuit laws.
II	The application of circuit laws in network theorems and graph theory to simplify complex networks.
III	The construction and working principle of DC generator, DC motor, andtypes of DC machines based on field excitation method.
IV	The theory of Faraday's law of mutual induction and working of single phase transformer.
V	The concept of rotating magnetic field and constructional features, principle and types of AC machines.

VII COURSE OUTCOMES:

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

CO 1	**Solve** complex electrical circuits by applying network reduction techniques for reducing into a simplified circuit.	Apply
CO 2	**Define** basic nomenclature of single phase AC circuits for obtaining impedance, admittance of series and parallel circuits.	Remember
CO 3	**Make use of** various network theorems and graph theory for simplifying complex electrical networks.	Apply
CO 4	**Demonstrate** the construction, principle and working of DC machines for their performance analysis.	Understand
CO 5	**Illustrate** working , construction and obtain the equivalent circuit of single phase transformers.	Understand
CO 6	**Explore** electromagnetic lawsused for the construction and opertaion of synchronous and asynchronous machines.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	1	Quiz

3 = High; 2 = Medium; 1 = Low

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

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	**PO 1**	Recollect the concept of electricity is described through scientific principles, importance Kirchhoff laws in relation with law of conservation of energy and charge circuits are explained using mathematics, engineering fundamentals and various source transformation techniques are adopted for solving complex circuits.	3
	PO 2	Derive standard expressions for equivalent resistances, inductances and capacitance by using series-parallel networks i.e mathematical calculations.	1
	PSO 1	Solve complex electrical circuits by applying basic circuit concepts by using computer programs.	1
CO 2	**PO 1**	Make use of Alternating quantity for obtaining form, peak factor concept of impedance and admittance using the knowledge of mathematics, science, and engineering fundamentals.	3
CO 3	**PO 1**	Demonstrate various network theorems in order to determine the same using principles of mathematics, science, and engineering fundamentals.	3
	PO 2	Verify various network theorems for their validation using mathematical calculations.	1
	PSO 1	Simplify complex electrical networks by applying various circuit theorems by using computer programs.	1
CO 4	**PO 1**	The principle of operation and characteristics of DC machines are explained by applying engineering fundamentals including device physics.	3
CO 5	**PO 1**	Understand how classification DC machines are done and their power flow with the knowledge of mathematics and engineering sciences.	3
	PSO 1	Develop equivalent circuit of single phase transformer referred to both sides by developing computer programs.	1
CO 6	**PO 1**	Understand the working of induction motors and alternators using engineering principles and mathematical equations.	3

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	10	-	-	-	-	-	-	-	-	-	-	25	-	-
CO 2	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	10	-	-	-	-	-	-	-	-	-	-	25	-	-
CO 4	100	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 5	100	-	-	-	-	-	-	-	-	-	-	-	25	-	-
CO 6	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	2	-	-	-	-	-	-	-	-	-	-	3	-	-
AVERAGE	3.0	0.3	-	-	-	-	-	-	-	-	-	-	0.5	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO ELECTRICAL CIRCUITS**
	Circuit concept: Ohm's law, Kirchhoff's laws, equivalent resistance of networks, Source transformation, Star to delta transformation, mesh and nodal analysis; Single phase AC circuits: Representation of alternating quantities, RMS, average, form and peak factor, concept of impedance and admittance.
MODULE II	**NETWORK THEOREMS AND NETWORK TOPOLOGY**
	Network Theorems: Superposition, Reciprocity, Thevenin's, Norton's, Maximum power transfer for DC excitations circuits. Network Topology: Definitions, Graph, Tree, Incidence matrix, Basic Cut Set and Basic Tie Set Matrices for planar networks.
MODULE III	**DC MACHINES**
	DC generators: Principle of operation, construction, EMF equation, types of DC generators. Losses and efficiency. DC motors: Principle of operation, back EMF, torque equation, types of DC motors, Losses and efficiency, numerical problems.
MODULE IV	**SINGLE PHASE TRASNFORMERS**
	Single Phase Transformers: Principle of operation, construction, types of transformers, EMF equation, operation of transformer under no load and on load, Phasor diagrams, equivalent circuit, efficiency, regulation and numerical problems.
MODULE V	**AC MACHINES**
	Three Phase Induction motor: Principle of operation, slip, slip -torque characteristics, efficiency and applications; Alternators: Introduction, principle of operation, constructional features, calculation of regulation by synchronous impedance method and numerical problems.

TEXTBOOKS

1. A Chakrabarti, "Circuit Theory", Dhanpat Rai Publications, 6thEdition,2004.
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3. WillianmHayt, Jack E Kemmerly S M Durbin, "Engineering Circuit Analysis", Tata McGraw Hill, 7thEdition,2010.
4. J P J Millman, C CHalkias, SatyabrataJit, "Millmans Electronic Devices and Circuits", Tata McGraw Hill, 2ndEdition,1998.

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WEB REFERENCES:

1. http://www.igniteengineers.com

2. http://www.ocw.nthu.edu.tw

3. http://www.uotechnology.edu.iq

COURSE WEB PAGE:

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

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO’s	Reference T1: 4.1
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	-
CONTENT DELIVERY (THEORY)			
2	Electrical Circuits: Basic definitions, Types of elements	CO 1	T1-5.2 to 5.3
3	Ohm’s Law, Kirchhoff Laws	CO 1	T1-5.4 to 5.5
4	Series, parallel circuits	CO 2	T1-5.5 to 5.8
5	Derivation for Star-delta and delta-star transformations	CO 2	T1-5.8 to 5.9
6	Mesh analysis and Nodal Analysis	CO 2	T1-5.11 to 5.12
7	Representation of alternating quantities	CO 3	T1-5.14 to 5.15
8	RMS and Average values of an AC signal	CO 2	T1-5.16 to 5.16

9	Form and peak factor, concept of impedance and admittance	CO 2	T1-5.16 to 5.16
10	Superposition theorem for DC excitations circuits	CO 3	T1-6.1 to 6.3
11	Reciprocity theorem for DC excitation	CO 3	T1-6.8 to 6.9
12	Thevenin's theorem for DC excitations circuits	CO 3	T1-6.2 to 6.3
13	Norton's theorem for DC excitations circuits	CO 3	T1-6.3 to 6.4
14	Maximum power transfer theorem for DC excitations circuits	CO 3	T1-11.1
15	Incidence matrix for planar networks	CO 3	T1-11.2 to 11.3
16	Basic Cut Set matrix for planar networks	CO 4	T1-11.2 to 11.3
17	Basic Tie Set matrix for planar networks	CO 3	T1-11.9 to 11.10
18	Principle of operation for DC generators	CO 4	R2-7.1 to 7.2
19	Construction and EMF equation for DC generators	CO 4	R2-7.4
20	Types of DC generators	CO 4	R2-7.3
21	Principle of operation for DC motors	CO 4	R2-7.3.1 to 7.3.2
22	Back EMF, torque equation for DC motors	CO 4	R2-7.3.3 to 7.3.6
23	Types of DC motors	CO 4	R2-7.6
24	Losses and efficiency for DC generators, motors	CO 4	T1-13.1 to 13.3
25	Principle of operation for Single Phase Transformers	CO 5	T1-13.1 to 13.3
26	Construction and EMF equation for Single Phase Transformers	CO 5	T1-13.5 to 13.6
27	Types of transformers and turns ratio	CO 5	T1-13.6 to 13.7
28	Operation of transformer under no load	CO 5	T1-13.7 to 13.9
29	Operation of transformer under on load	CO 5	T1-13.8
30	Equivalent circuit for Transformers	CO 5	T1-17.1 to 17.2
31	Phasor diagrams of transformer	CO 5	T1-17.3 to 17.4
32	Losses of Transformers	CO 5	T1-17.6 to 17.7
33	Efficiency of Transformers	CO 5	T1-13.11
34	Regulation for Transformers	CO 5	T1-13.12
35	Three Phase Induction motor: Principle of operation	CO 5	T1-13.13
36	slip, slip -torque characteristics	CO 6	T1-13.14

37	Efficiency of Induction motor	CO 6	T1-13.16 to 13.18
38	Applications of Induction motor	CO 6	T1-13.19
39	Alternators: Introduction, principle of operation	CO 6	T1-13.19
40	Constructional features	CO 6	T1-13.20
41	Calculation of regulation by synchronous impedance method and numerical problems.	CO 6	T1-13.20
PROBLEM SOLVING/ CASE STUDIES			
42	Numerical Examples on electrical quantities, Ohm's law, KCL, KVL	CO 2	T1-5.8 to 5.9
43	Numerical Examples on series, parallel elements and star to delta transformation and mesh analysis	CO 2	T1-5.5 to 5.8
44	Numerical Examples on nodal analysis and alternating quantities	CO 3	T1-6.8 to 6.9
45	Numerical Examples on Superposition theorem	CO 3	T1-6.2 to 6.3
46	Numerical Examples on reciprocity and maximum power transfer theorems	CO 3	R2-7.1 to 7.2
47	Numerical Examples on Thevenin's and Norton's theorems	CO 3	T1-13.1 to 13.3
48	Numerical Examples on Basic cut set and Tie set matrices	CO 3	T1-13.5 to 13.6
49	Numerical Examples on EMF equation and types of DC generators	CO 4	T1-13.6 to 13.7
50	Numerical Examples on torque equation of DC motor	CO 4	T1-13.1 to 13.3
51	Numerical Examples on types of DC motors	CO 4	T1-13.13
52	Numerical Examples on EMF equation and equivalent circuit of 1 phase transformer	CO 5	T1-13.16 to 13.18
53	Numerical Examples on, efficiency for Transformers	CO 5	T1-13.14
54	Numerical Examples on, regulation for Transformers	CO 5	T1-13.16 to 13.18
55	Numerical Examples on EMF of Alternators	CO 6	T1-13.19
56	Numerical Examples on regulation of Alternators	CO 6	T1-13.20
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Definitions and terminology from basics of electrical circuits	CO 1	T1-5.1 to 5.3
58	Definitions on network theorems	CO 3	T1-6.1 to 6.3
59	Definitions on DC machines	CO 4	R2-7.1 to 7.2
60	Definitions on single phase transformers	CO 5	T1-13.1 to 13.3
61	Definitions on AC machines	CO 6	T1-13.11
DISCUSSION OF QUESTION BANK			
62	Questions from electrical circuits	CO 1	T1-5.1 to 5.3

63	Questions from network theorems	CO 3	T1-6.1 to 6.3
64	Questions from DC machines	CO 4	R2-7.1 to 7.2
65	Questions from single phase transformers	CO 5	T1-13.1 to 13.3
66	Questions from AC machines	CO 6	T1-13.11

Mrs T Saritha Kumari, Asst Professor **HOD,ME**

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

Course Title	**MANUFACTURING PRACTICE**					
Course Code	AMEC02					
Program	B. Tech					
Semester	II					
Course Type	FOUNDATION					
Regulation	IARE-UG20					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	-	-	-	2	1	
Course Coordinator	Mr. B. Vijaya Krishna, Assistant Professor					

I COURSE OVERVIEW:

Manufacturing Practice is intended to enhance the learning experience of the student about Engineering tools for cutting and measuring used in a workshop. Students are expected to gain experience in hands on training as well as knowledge to carry out a particular process for making a product using the basic manufacturing devices used in Workshop.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
-	-	-	-	-

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Manufacturig Practice	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing Further Experiments

V EVALUATION METHODOLOGY:

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

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

The emphasis on the experiments is broadly based on the following criteria 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.

A. Experiment Based

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

B. Programming Based

Purpose	**Algorithm**	**Program**	**Conclusion**	**Viva**	**Total**
-	-	-	-	-	-

VI HOW PROGRAM OUTCOMES ARE ASSESSED:

Program outcomes		**Strength**	**Proficiency Assessed by**
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises
PO 3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	CIA

PO 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	2	Lab Exercises
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	3	SEE

3 = High; 2 = Medium; 1 = Low

VII HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

VIII COURSE OBJECTIVES:

The students will try to learn:

I	The application of jigs and fixtures, measuring, marking and cutting tools in various types of manufacturing processes.
II	The preparation of different joints in carpentry and fitting and also familiarizes wood working machinery.
III	The concepts of forming processes by forging, black-smithy and tin-smithy with an application extracts of Engineering Drawing.
IV	The standard electrical wiring practices for domestic and industrial appliances. of Engineering Drawing.
V	The current advancements in developing the prototype models through digital manufacturing facilities.

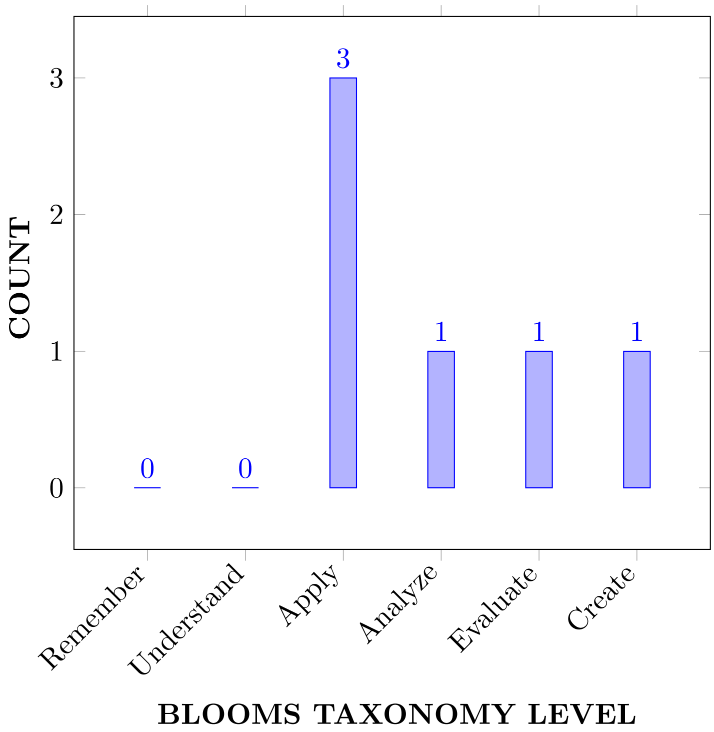
IX COURSE OUTCOMES:

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

CO 1	**Identify** the conventional representation of materials and machine elements of various machining processes such as moulding and machine shop.	Apply
CO 2	**Determine** the ability to Produce Fitting and welding jobs as per specified dimensions in addition to demonstrating proficiency with hand tools common to fitting.	Evaluate
CO 3	**Create** works of metal art using fire and furnace to convert given shape into useable elements using basic blacksmith techniques.	Create
CO 4	**Organize** the moulding techniques for producing casting of different and complex shapes using various patterns.	Apply

CO 5	**Develop** various engineering and household articles such as tin boxes, cans, funnels, ducts etc., from a flat sheet of metal.	Apply
CO 6	**Compare** various wiring diagrams using conduit system of wiring and Prepare different types of wiring joints on the given circuit boards using appropriate electrical tools.	Analyze

COURSE COURSE KNOWLEDGE COMPETENCY LEVEL:



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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the knowledge of engineering fundamentals to join given wooden pieces according to given sketch to develop required joint.	1
	PO 3	Conversion of given design into a practical output using design solution for complex engineering problems and design system components	2
	PO 5	Develop the given resources and engineering tools into proper fitment as given in the diagrammatical representation.	2
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2

	PSO 3	Make use of Experimental tools for Building Career Paths towards Innovation Startups, Employability in different mechanical trades.	2
CO 2	PO 1	Apply the knowledge of engineering fundamentals to join given metal pieces according to given sketch to develop required joint.	1
	PO 5	Develop the given resources and engineering tools into proper fitment as given in the diagrammatical representation.	2
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2
	PSO 3	Make use of Experimental tools for Building Career Paths towards Innovation Startups, Employability in different mechanical trades.	2
CO 3	PO 1	Apply the knowledge of engineering fundamentals to make metal rod into given required shape according to given sketch to develop required joint.	1
	PO 5	Develop the given resources and engineering tools into required shape as given in the diagrammatical representation.	2
	PSO 3	Make use of Experimental tools for Building Career Paths towards Innovation Startups, Employability in different mechanical trades.	2
CO 4	PO 1	Apply the knowledge of engineering fundamentals to make the casting product from given materials according to given sketch to develop required shape.	1
	PO 3	Conversion of given design into a practical output using design solution for complex engineering problems and design system components.	2
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2
CO 5	PO 5	Develop the given resources and engineering tools into required shape as given in the diagrammatical representation.	2
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	
CO 6	PO 1	Apply the knowledge of engineering fundamentals to make the required electrical connection according to given circuit diagram to develop connection.	1
	PO 5	Develop the given resources and engineering tools into proper fitment as given in the diagrammatical representation.	2

	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2
	PSO 3	Make use of Experimental tools for Building Career Paths towards Innovation Startups, Employability in different mechanical trades.	2

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PROGRAM OUTCOMES				Program Specific Outcomes
	PO 1	PO 3	PO 5	PO 11	PSO 3
CO 1	1	2	2	2	2
CO 2	1	2		2	2
CO 3	1		2		2
CO 4	1	2		2	
CO 5			2	2	
CO 6	1		2	2	2

3 = High; 2 = Medium; 1 = Low

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK 1	**CARPENTRY-I**
	Batch I: Preparation of Tenon joint as per given dimensions. Batch II: Preparation of Mortise joint as per given taper angle.
WEEK 2	**CARPENTRY-II**
	Batch I: Preparation of dove tail joint as per given taper angle. Batch II: Preparation of lap joint as per given dimensions.

WEEK 3	**FITTING**
	Batch I: Make a straight fit for given dimensions. Batch II: Make a square fit for given dimensions.
WEEK 4	**ELECTRICAL AND ELECTRONICS**
	Batch I: Make an electrical connection to demonstrate domestic voltage and current sharing. Batch II: Make an electrical connection to control one bulb with two switches-stair case connection.
WEEK 5	**BLACKSMITHY- I, TINSMITHY- I**
	Batch I: Prepare S-bend for given MS rod using open hearth furnace. Batch II: Prepare Prepare the development of a surface and make a rectangular tray and a round tin.
WEEK 6	**TINSMITHY- I, BLACKSMITHY- I**
	Batch I: Prepare the development of a surface and make a rectangular tray and a round tin. Batch II: Prepare S-bend and J-bend of given MS rod using open hearth furnace.
WEEK 7	**MOULD PREPARATION-I**
	Batch I: Prepare a wheel flange mould using a given wooden pattern. Batch II: Prepare a bearing housing using an aluminum pattern.
WEEK 8	**MOULD PREPARATION-II**
	Batch I: Prepare a bearing housing using an aluminum pattern. Batch II: Prepare a wheel flange mould using a given wooden pattern.
WEEK 9	**WELDING**
	Batch I: Arc welding and Gas Welding. Batch II: Gas welding and Arc Welding.
WEEK 10	**INJECTION MOULDING**
	Batch I: Injection moulding Batch II: Injection moulding.
WEEK 11	**BLOW MOULDING**
	Batch I: Blow moulding. Batch II: Blow moulding..
WEEK 12	**MACHINE SHOP-Turning and Milling**
	Batch I: Working on central lathe and shaping machine. Working on milling machine.
	Batch II: Working on central lathe and shaping machine. Working on milling machine.
WEEK 13	**ADVANCED MACHINE SHOP-I**
	Batch I: Working on CNC Turning machines. Working on CNC Vertical Drill Tap Center.
	Batch II: : Working on CNC Turning machines. Working on CNC Vertical Drill Tap Center.

WEEK 14	**ADVANCED MACHINE SHOP-II**
	Batch I: Working on CNC Laser Engraving Machine. Working on 5 Axis CNC Routing Machine..
	Batch II: : Working on CNC Laser Engraving Machine. Working on 5 Axis CNC Routing Machine.

TEXTBOOKS

1. Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., Elements of Workshop Technology, Media promoters and publishers private limited, Mumbai, Vol. I 2014 and Vol. II 2012.
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3. Gowri P. Hariharan, A. Suresh Babu, Manufacturing Technology – I, Pearson Education, 2011.
4. Roy A. Lindberg, Processes and Materials of Manufacture, Prentice Hall India, 4 th Edition, 1998.
5. Rao P.N., Manufacturing Technology, Vol. I and Vol. II, Tata McGraw-Hill House, 2017

REFERENCE BOOKS:

1. Gowri P. Hariharan, A. Suresh Babu, Manufacturing Technology – I, Pearson Education, 2012.
2. Roy A. Lindberg, Processes and Materials of Manufacture, Prentice Hall India, 4th Edition, 2008.
3. Rao P.N., Manufacturing Technology, Vol. I and Vol. II, Tata McGraw-Hill House, 2017.

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	Tenon joint and Mortise joint.	CO 1, CO 2	T1:1.4, R1:1.2
2	Dove tail joint and Lap joint.	CO 1, CO 2	T1:1.5, R1:1.3
3	Straight fit and Square fit.	CO 3, CO 4	T2:12.2, R2:13.1
4	V fit and Semicircular fit.	CO 3, CO 4	T2:12.3, R2:13.4
5	S-bend and J-bend.	CO 5, CO 6	T3:9.1, R3:3
6	Fan and Round to Square shape.	CO 5, CO 6	T3:9.1, R3:3
7	Wheel flange and bearing housing.	CO 7, CO 8	T4:1.9, R2:1.8
8	Bearing housing and Wheel flange.	CO 7, CO 8	T4:2, R2:1.9

9	Rectangular tray and Round tin.	CO 9, CO 10	T5:1.4, R1:1.2
10	Make a Square Tin and Conical Funnel.	CO 9, CO 10	T5:1.7, R2:1.3
11	Series connection and parallel Connection.	CO 11, CO 12	T4:1.4, R1:1.2
12	One bulb controlled by two switches and tube light connection.	CO 11, CO 12	T5:7.1, R3:3.8

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Divided Tenon Joint:** It is the simplest form of Mortise and tenon joint and this joint is made by fitting a short tenon into a continuous groove. This joint has the advantage of being easy to cut and is often used to make cabinet doors and other light duty frame and panel assemblies.
2	**Cross Fitting:** It is the fundamental of type of fitting which are used fitting trade and it is formed by joining the two inclined shaped cut specimens together and is often used to join the universal bearings.
3	**Hexagonal Headed Bolt:** Hexagonal bolts are large bolts with a six-sided head used to fasten wood to wood, or metal to wood. These will have a tendency to spin as you tighten them.
4	**Open scoop:** Open scoop is used for accurately dispensing powders and granules hygienically. It is suitable for any hygienic application.
5	**T-Pipe Joint:** T-pipe is a type of fitting which is T-shaped having two outlets at 90 degrees to the main line. It is short piece of pipe with a lateral outlet.it is widely used as pipe fittings.
6	**Grooved Pulley:** Grooved pulley often used to for holding a belt, wire rope or rope and incorporated into a pulley. These sheave pins on a axle or bearing inside the frame of the pulley. This allows wire or rope to move freely, minimizing friction and wear on the cable.
7	**Bell Indicator circuit:** Bell indicator circuit is used where a bell and buzzers are needed to control from different locations. Bell indicator circuit is also known as hoteling circuit where an electric bell is controlled from more than one locations.

Prepared by: **HOD,ME**

Mr. B. VijayaKrishna Assistant Professor

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

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**COMPUTER AIDED ENGINEERING DRAWING**				
Course Code	AMEC03				
Program	B.Tech				
Semester	II	ME			
Course Type	Core				
Regulation	UG 20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Mr. R.Srinivas, Assistant Professor				

I COURSE OVERVIEW:

Drawing is the accurate technique that develops the ability to visualize any object with all physical and dimensional configurations. During the process of design, the designer may have to carry out a large amount of computations to generate optimum design and develops engineering drawings for manufacturing a product using interactive computer graphics. The computer aided engineering drawing assists in preparation of 3D and 2D drawings to carry out sophisticated design and analysis. This course forms the foundation for the development of computer graphics and CAD/CAM technologies in the era of digital manufacturing

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSC02	I	Linear Algebra and Calculus

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Computer Aided Engineering Drawing	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Open Ended Experiments	✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

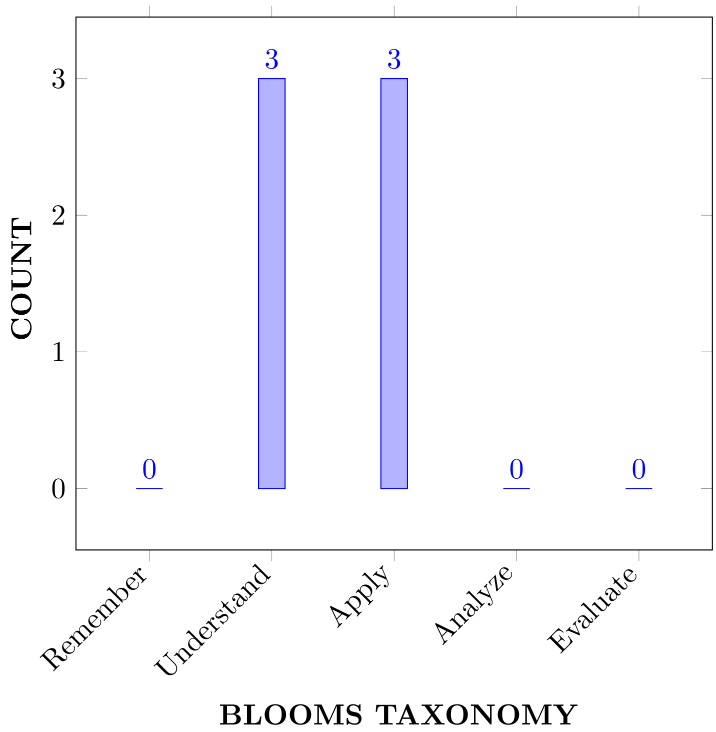
I	The basic knowledge about engineering drawing as a communicative language of engineers in ideation.
II	The ability to visualize, create and edit any object with all the physical and dimensional configurations using computer aided drawing tools.
III	The code of engineering drawing practice as per the Bureau of Indian Standards and International practices.

VII COURSE OUTCOMES:

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

CO 1	**Illustrate** bureau of Indian standards conventions of engineering drawing with basic concepts, ideas and methodology for different geometries and their execution. .	Understand
CO 2	**Apply** the commands used in AutoCAD for development of multi-aspect sketches, additional and sectional view.	Apply
CO 3	**Construct** parabolic, Hyperbolic and elliptical curves for profiles likes buildings and bridges. **Build** Cycloidal and involutes profiles for developing new products like gears and other engineering applications.	Apply
CO 4	**Explain** various types of scales for engineering applications like maps, buildings, bridges.	Understand
CO 5	**Explain** the concept of projection of solids inclined to both the planes for interpretation of different views and orthographic projection concepts in solid modeling.	Understand
CO 6	**Recall** the orthographic projection concepts in solid modeling for use in conversation to isometric and Vice-versa	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3	CIA
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	Videos

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies. .	3	Assignments/ Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Recall the basic commands of AutoCAD for various curves and scales using **scientific principles** and **engineering fundamentals**.	2
	PO 5	Understand Scales and Curves with different methods conceptually and apply them in modeling a **complex engineering** activity	1
	PSO 3	Make use of design **computational** and modeling **experimental** tools for building career paths towards innovative startups to be an entrepreneur.	2

CO 2	PO 1	Recall the basic commands of AutoCAD for various drawings and draw using **scientific principles** and **engineering fundamentals**.	2
	PO 3	Understand the given **problem statement** related to question formatted for engineering drawings and based upon type use different AutoCAD commands .	1
CO 3	PO 1	Develop expression for eccentricity and Identify the appropriate type of curve for **problem solving** using **engineering sciences**.	2
	PO 3	Use research based knowledge for different methods of drawing engineering curves and draw with **modern tools** .	3
CO 4	PO 1	Apply the **engineering knowledge** to classify Cycloidal and involutes profiles in user Coordinate System to draw engineering problems.	1
	PO 3	Build practical experience in building the real time products, **using industry standard** and **collaboration technique** in the field of curves.	2
CO 5	PO 5	Recall various types of scales and **use principles of BIS**, and **engineering fundamentals** for engineering applications like maps, buildings, bridges. .	2
CO 6	PO 1	Make a use of an appropriate plane to draw different position of points and lines to solve **engineering problems** for **solution enhancement**	2
	PO 5	Recall various positions in coordinate system for points and lines **use principles of views**, and **engineering fundamentals** for completing the drawing	2

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

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

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**INTRODUCTION TO ENGINEERING DRAWING**
	Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering..
WEEK II	**OVERVIEW OF COMPUTER GRAPHICS**
	Listing the computer technologies that impact on graphical communication, Demonstrating knowledge of the theory of CAD software
WEEK III	**OVER VIEW OF COMPUTER AIDED DRAFTING**
	Practial session of ACAD editing and Modify Commands and practice.
WEEK IV	**CONIC SECTIONS**
	Conic sections including the Rectangular Hyperbola (General method only); Cycloid, Epicycloid, Hypocycloid and Involute
WEEK V	**DRAWING PAPER SIZES AND SCALES**
	Drawing paper standards and Scales-Plain, Diagonal and Vernier Scales
WEEK VI	**PROJECTION OF POINTS**
	Principles of Orthographic Projections-Conventions-Projections of Points and lines inclined to both planes..
WEEK VII	**PROJECTION OF LINES**
	Projections of planes, Planes inclined to both the planes.
WEEK VIII	**PROJECTION OF REGULAR SOLIDS**
	Draw the orthographic views of geometrical solids of Prism, Pyramid, Cylinder and Cone.
WEEK IX	**ISOMETRIC PROJECTIONS**
	Principles of Isometric projection–Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids;.
WEEK X	**ORTHOGRAPHIC PROJECTIONS**
	Conversion of Isometric Views to Orthographic Views and Vice-versa
WEEK XI	**INTRODUCTION TO 3D**
	Setting environment for 3D drawings and UCS
WEEK XII	**PLOTTING AND TYPES OF EXPORTING DRAWING**
	Understanding how to export the drawing in other usable formats

TEXTBOOKS

1. . N. D. Bhatt, "Engineering Drawing", Charotar Publications, New Delhi, 49th Edition, 2010.
2. C.M. Agarwal, Basant Agarwal, "Engineering Drawing", Tata McGraw Hill, 2nd Edition, 2013.

REFERENCE BOOKS:

1. K. Venugopal, "Engineering Drawing and Graphics". New Age Publications, 2nd Edition, 2010.
2. Dhananjay. A. Johle, "Engineering Drawing", Tata McGraw Hill, 1st Edition, 2008.

3. S.Trymbaka Murthy, "Computer Aided Engineering Drawing", I.K. International Publishers, 3rd Edition, 2011.
4. A.K.Sarkar, A.P Rastogi, "Engineering graphics with Auto CAD", PHI Learning, 1stEdition, 2010.

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	Principles of engineering drawing – Geometrical construction.	CO 1	T1:1.4 R1:1.2
2	Principles of dimensions and their execution. Introduction to auto-cad.	CO 1, CO2	T1:1.5 R1:2.4
3	Familiarization of auto-cad commands. Draw and modify commands, dimensions, line properties, status bar, etc..,	CO 2	T1:2.5 R1:2.5
4	Construction of Ellipse – General method	CO 3	T2:2.5 R1:2.6
5	Construction of parabola curves. – General method	CO 3	T1:22.7
6	Construction of hyperbola curves- General method	CO 3	T1:6.3 R2:5.3
7	Construction of various curves cycloid, epicycloids, hypocycloid and involutes	CO 4	T1:7.5 R1:6.3
8	Construction of various scales for engineering use- plain, diagonal, and vernier.	CO 5	T1:8.5 R1:6.8
9	Projection of points and lines inclined to single plane and both the planes.	CO 6	T1:12.2 R3:13.1
10	Projection of planes- inclined to single plane and both the planes.	CO 5	T1:12.3 R1:13.2
11	Projection of solids inclined tosingle plane and both the planes.	CO 4	T1:1.4 R1:1.2
12	Draw the basic isometric views. Convert the pictorial views to orthographic views and vice versa.	CO 5	T1:1.5 R1:2.4

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Demonstration of twin vortex :** formation and calculation of vortex size for different geometries.
2	**Construction of hyperbolic curves:** –rectangle method, and parallelogram methods..
3	**Draw the development** of lateral surfaces of cube
4	**Draw the development** of lateral surfaces of prism
5	**Draw the development** of lateral surfaces of pyramid
6	**Draw the development** of lateral surfaces of cylinder
7	**Draw the development** of lateral surfaces of cone

Signature of Course Coordinator **HOD,ME**
R.Srinivas, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	PROGRAMMING FOR PROBLEM SOLVING LABORATORY				
Course Code	ACSC03				
Program	B.Tech				
Semester	II	ME			
Course Type	Foundation				
Regulation	IARE - R20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Ms. K Aswini, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	ACSC03	II	-

II COURSE OVERVIEW:

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

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

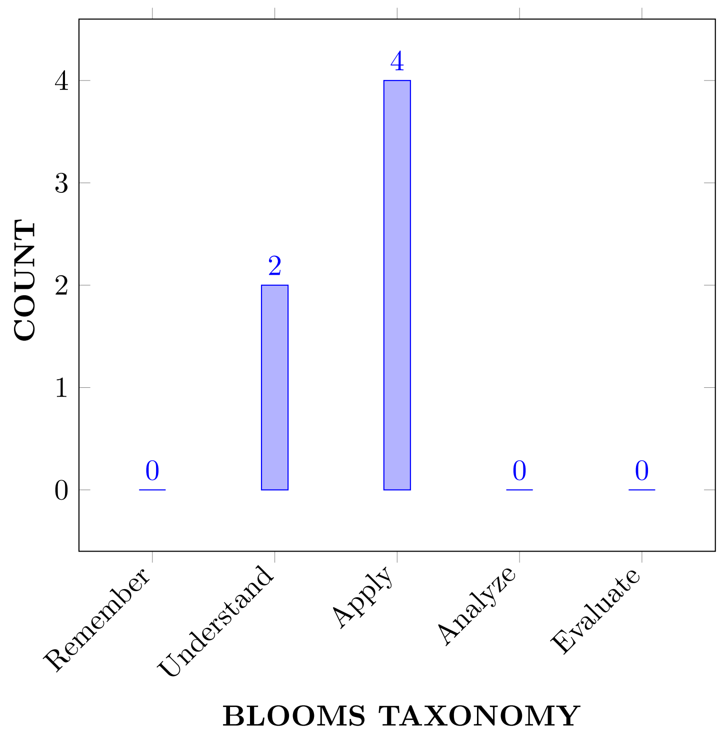
I	The hands on experience in design, develop, implementation and evaluation by using Asymptotic notation.
II	The demonstration knowledge of basic abstract data types (ADT) and associated algorithms for organizing programs into modules using criteria that are based on the data structures of the program.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

VII COURSE OUTCOMES:

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

CO 1	**Demonstrate** the basic concepts of python programming awith the help of data types,operators and expressions, console input/output.	Apply
CO 2	**Make use of** control statements for altering the sequential execution of programs in solving problems.	Analyze
CO 3	**Demonstrate** operations on built-in container data types (list, tuple, set, dictionary) and strings.	Apply
CO 4	**Make use of** operations and applications on strings with the help of builtin functions.	Apply
CO 5	**Solve** the problems by using modular programming concepts throughfunctions.	Apply
CO 6	**Identify** tobject-oriented programming constructs for developing large,modular and reusable real-time programs	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining. .	2	Viva-voce Laboratory Practices
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications. .	2	Viva-voce Laboratory Practices
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies. .	2	Viva-voce Laboratory Practices

3 = High; 2 = Medium; 1 = Low

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

Courses Outcomes	Program Outcomes						Program Specific Outcomes		
	PO 1	PO 2	PO 3	PO 5	PO 10	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	2	2	2	2	2	2	2	2
CO 2	-	-	7	-	-	-	1	2	-
CO 3	3	-	-	-	-	-	4	-	-
CO 4	2	1	-	1	-	-	4	-	-
CO 5	2	4	5	-	-	-	-	2	-
CO 6	3	7	-	-	-	-	3	-	-

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**STUDENTS IN A COLLEGE**
	1.There are D departments in a college and each department has Ai number of students. Your task is to find the total number of students in the college. Output Format: A single integer(the total number of students in the college) Example: Input: 3 1 2 3 Output: 6 2. In Statistics, range is defined as the difference between highest and lowest values. Given marks of students in a class, find the range. Input Format: The first line of input contains an integer N, the number of students The second line of input contains N space-separated integers denoting the marks of each student in the class. Output Format: A single integer(the range) Example: Input: 5 10 20 40 20 30 Output: 30
WEEK II	**TRIANGLES**
	1. What is the maximum number of squares of size 2x2 that can be fit in a right angled isosceles triangle of base B. One side of the square must be parallel to the base of the isosceles triangle. Base is the shortest side of the triangle. Input Format: The first line of input contains an integer T , denoting number of test cases. Each of the next T lines contain a single integer , B (base) Output Format: For each test case , print a single integer, the number of squares. Example: Input: 3 1 1 4 11 Output: 0 0 1 10 2.Given 3 sides of a triangle, check whether the given three sides form a triangle and if so , check if it is an equilateral , isosceles or scalene triangle, also print its area. Input Format: The first line of input contains an integer T , denoting number of test cases. Each of the next T lines contain 3 space separated integers , the 3 sides Output Format: For each test case , if the given 3 sides form a triangle , Print ―EQUILATERAL‖ / ―ISOSCELES‖ /‖SCALENE‖ followed by the area (up to 2 decimal places) If they do not form a triangle , print ―NOT A TRIANGLE‖ Example: Input: 5 3 3 3 3 5 3 3 7 3 4 2 3 1 2 3 Output: EQUILATERAL 3.89 ISOSCELES 4.14 NOT A TRIANGLE SCALENE 2.90 68 ― P a g e NOT A TRIANGLE
WEEK III	**MAGIC SQUARE**
	1. A magic square of size N is a square matrix of order NxN that satisfies these conditions. a. It should contain all elements from 1 to N2 without repetitions. b. The sum of the numbers in any row,column or diagonal should be equal. Write a Python program to check whether a given matrix is a magic square or not Input Format: The first line of input contains an integer N, the order of the square matrix Each of the next N lines contain N-space separated integers denoting the elements of the matrix Output Format: Print ―YES‖ if it is a magic square, else print ―NO‖. Example: Input: 3 8 1 6 3 5 7 4 9 2 Output: YES

WEEK IV	**RUNNING RACE**
	1. The scores of participants in a running race are given, find the runner up. Input Format: The first line of input contains an integer T, the number of test cases Each of the next T lines contain some space separated integers denoting the participant‘s scores Output Format: For each test case, print a single integer denoting the score of the runner up. If there is no runner up, print ―NONE‖. Example: Input: 5 1 2 3 4 5 5 5 5 5 2 5 5 2 5 5 5 5 5 10 20 30 40 50 19 76 89 12 34 78 90 90 76 89 90 Output: 4 2 NONE 40 89 2. The scores of participants in a running race were recorded but the person recording the scores made some errors and added some duplicate entries. Remove all duplicate entries and print the count of the errors made. Input Format: The first line of input contains an integer N, the number of scores that were recorded The second line of input contains N space-separated integers denoting the recorded scores. 69 — P a g e Output Format: The first line of output should contain the distinct scores after removing duplicate entries. The second line of output should contain an integer denoting the number of errors made. Example: Input: 10 1 2 3 1 1 3 4 2 8 9 Output: 1 2 3 4 8 9 4
WEEK V	**PANGRAM**
	1. Given a string check if it is Pangram or not. A pangram is a sentence containing every letter in the English Alphabet. Ignore case and special characters. Input Format: The first line of input contains an integer T, the number of test cases. Each of the following T lines contain a string Output Format: For each test case, print ―PANGRAM‖ or ―NOT PANGRAM‖. Example: Input: 3 The quick brown fox jumps over the lazy dog $!# ABC DEF ghi jkl mnop qrst uvw XYZ @#!$ Institute of Aeronautical Engineering Output: PANGRAM PANGRAM NOT PANGRAM
WEEK VI	**FREQUENCY OF LETTERS**
	1. Given a sentence, print the frequency of each English letter present in the sentence, in alphabetic order. Consider all characters to be lowercase. Input Format: A sentence Output Format: For every character, print the character followed by a hyphen and then the frequency (in alphabetic order). Ignore digits and special characters and consider uppercase letters also as lowercase. Example: Input: 12345 This is a sentence @IARE Output: a-2 c-1 e-4 h-1 i-3 n-2 70 — P a g e r-1 s-3 t-2 .
WEEK VII	**BINARY NUMBERS**
	1. Write a program to convert a given decimal number into binary Input Format: The first line of input contains an integer T denoting the number of test cases. Each of the next T lines contains decimal integers. Output Format: For each test case, print the binary equivalent. Example: Input: 4 1 3 5 10 Output: 1 11 101 1010 2. Write a program to convert a given binary number into decimal form. Input Format: The first line of input contains an integer T denoting the number of test cases. Each of the next T lines contains binary integers. Output Format: For each test case, print the decimal equivalent. Example: Input: 4 1 11 101 1001 Output: 1 3 5 9 .
WEEK VIII	**PATTERNS**
	1. Write a Python program to print the following pattern. N=5 * *** ***** *** * 2. Write a Python program to print the following pattern. S= SCHOOL IIIIII IAAAAAI IARRRAI IARERAI IARRRAI IAAAAAI IIIIII

WEEK IX	**COMBINATIONS**
	1. Given an array of size n, generate and print all possible combinations of r elements in array. Input Format: First line contains Space-separated integers denoting array elements. Second line contains r , size of each combination Output Format: Print each combination in a separate line and every combination should have comma separated integers. Example: Input: 1 2 3 4 2 Output: 1,2 1,3 1,4 2,3 2,4 3,4
WEEK X	**CLASS AND OBJECTS**
	1. Create a Temperature class. Make two methods. i. Convert Fahrenheit - It will take Celsius and will print it into Fahrenheit. ii. Convert Celsius - It will take Fahrenheit and will convert it into Celsius. 2. Create a Time class and initialize it with hours and minutes. i. Make a method add Time which should take two time object and add them. E.g.- (2 hour and 50 min) + (1 hr and 20 min) is (4 hr and 10 min) ii. Make a method display Time which should print the time. iii. Make a method Display Minute which should display the total minutes in the Time. E.g.- (1 hr 2 min) should display 62 minute.
WEEK XI	**ROMAN NUMERAL**
	1. Write a Python program to convert a decimal number into its roman numeral form. Input Format: The first line of input contains an integer T denoting the number of test cases. Each of the next T lines contains decimal integers. Output Format: For each test case, print the roman numeral equivalent. Example: Input: 4 10 100 999 2020 Output: X C CMXCIX MMXX 2. Write a Python program to convert a roman numeral into its decimal form. Input Format: The first line of input contains an integer T denoting the number of test cases. Each of the next T lines contains roman numbers. Output Format: For each test case, print the decimal equivalent. Example: Input: 4 XII C DXCVII MMXX Output: 12 100 597 2020
WEEK XII	**FILE HANDLING**
	Write a Python program that uses functions to perform the following: a. Create a binary search tree. Example: Input File: First line Second line Third line 73 — P a g e Output: Characters:31 Words:6 Lines:3 b. Traverse the above binary search tree recursively in pre-order, post-order and in-order. Count the number of nodes in the binary search tree. Example: Input File: First line Second line Third line Output: 1. First line 2. Second line 3. Third line

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1. 1. Michael H Goldwasser, David Letscher, —Object Oriented Programming in Python‖, Prentice Hall, 1st Edition, 2007.

   2. Yashavant Kanetkar, Aditya Kanetkar, —Let us Python‖, BPB publication, 1st Edition, 2019. 3. Ashok Kamthane, Amit Kamthane, —Programming and Problem Solving with Python‖, McGraw Hill Education (India) Private Limited, 2018. 4. Taneja Sheetal, Kumar Naveen, —Python Programming – A modular approach‖, Pearson, 2017. 5. R Nageswara Rao, —Core Python Programming‖, Dreamtech Press, 2017 Edition.

WEB REFERENCE

1. 1. https://www.codesdope.com/practice/python-your-class/ 2. https://www.geeksforgeeks.org/python-programming-language/ 3. https://www.hackerrank.com/ 4. https://www.codechef.com/

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Calibration of Venturimeter and Orifice meter.	CO 1	R1: 1.2
2	Determination of pipe flow losses in rectangular and circular pipes.	CO 2	R2: 3.5
3	Verification of Bernoulli's theorem	CO 3	R1: 3.4
4	Determination of Reynolds Number of fluid flow	CO 4	R1: 2.2
5	Determine the reaction forces produced by the change in momentum.	CO 5	R1: 2.4
6	Determine the efficiencyand draw theperformance curves ofcentrifugal pump.	CO 6	R3: 4.5
7	Determine the efficiencyand draw theperformance curves of reciprocating pump.	CO 6	R3: 4.6
8	Determine the performance characteristics of pelton wheel under constant head.	CO 6	R2: 5.1
9	Determine the performance characteristics of Francis turbine.	CO 6	R2: 5.2
10	Determine the rate of flow through weir.	CO 6	R1: 7.1
11	Determine the rate of flow through Nothches.	CO 6	R1:7.2
12	Determine the rate of flow through a Orifice meter	CO 6	R1:7.3

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

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

Signature of Course Coordinator **HOD,MECH**
Ms K.Aswini, Assistant Professor

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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**PROBABILITY AND STATISTICS**				
Course Code	AHSC08				
Program	B.Tech				
Semester	III	ME			
Course Type	Foundation				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Ms. P Naga Lakshmi Devi, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

II COURSE OVERVIEW:

Probability theory is the branch of mathematics that deals with modelling uncertainty. Inferential Statistics and regression analysis together with random variate distributions are playing an exceptional role in designing data driven technology which is familiarly known as data centric engineering. They also have wide variety applications in telecommunications and other engineering disciplines. The course covers advanced topics of probability and statistics with applications. The course includes: random variables, probability distributions, hypothesis testing, confidence intervals, and linear regression. There is an emphasis placed on real-world applications to engineering problems.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Probability and Statistics	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

Alternative Assessment Tool (AAT)

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

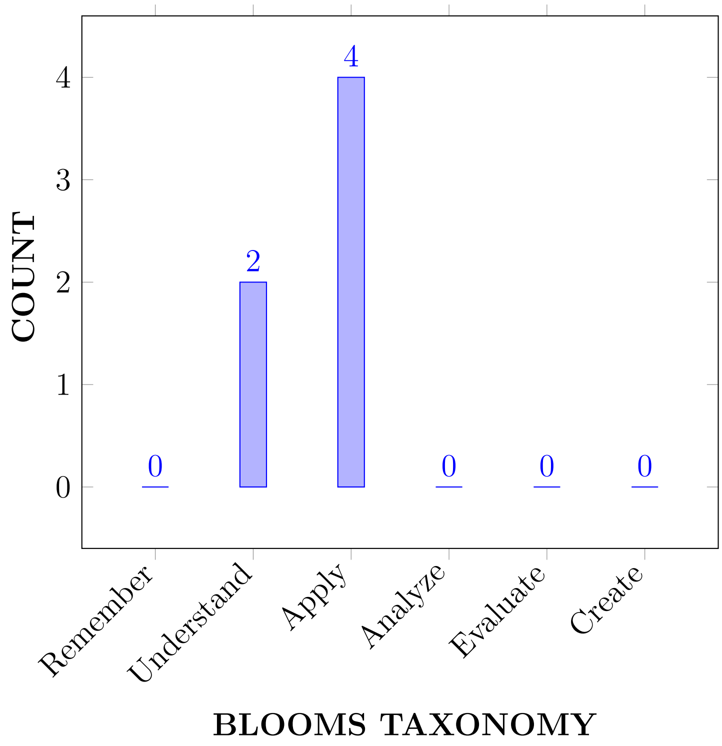
I	The theory of random variables, basic random variate distributions and their applications.
II	The Methods and techniques for quantifying the degree of closeness among two or more variables and the concept of linear regression analysis.
III	The Estimation statistics and Hypothesis testing which play a vital role in the assessment of the quality of the materials, products and ensuring the standards of the engineering process.
IV	The statistical tools which are essential for translating an engineering problem into probability model.

VII COURSE OUTCOMES:

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

CO 1	**Explain** the role of random variables and types of random variables, expected values of the discrete and continuous random variables under randomized probabilistic conditions.	Understand
CO 2	**Interpret** the parameters of random variate Probability distributions such as Binomial, Poisson and Normal distribution by using their probability functions, expectation and variance.	Understand
CO 3	**Apply** Bivariate Regression as well as Correlation Analysis for statistical forecasting.	Apply
CO 4	**Make Use of** estimation statistics in computing confidence intervals, Regression analysis and hypothesis testing.	Apply
CO 5	**Identify** the role of statistical hypotheses, types of errors, confidence intervals, the tests of hypotheses for large samplein making decisions over statistical claims in hypothesis testing	Apply
CO 6	**Identify** the tests of hypothesis for small sample in making decisions over statistical claims in hypothesis testing	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	3	CIE/Quiz/AAT
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Seminar/ Conferences/ Research Papers
PO 5	**Modern Tool Usage:** Use research-based knowledge and research methods including design of eConduct investigations of complex problems:xperiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	Assignments/ Discussion

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	-	-
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	-	-
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	-	-

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	**PO 1**	Explain (understanding) the concept of random variables and their role in solving complex engineering problems involving random events and uncertainty by using Mathematical functions (principles of mathematics).	2
	PO 4	Understand the technical uncertainty prevailing in the probabilistic situations with aids of technical literature and quantitatively measure The expected values, variances of the modeled discrete random variables in a systematic approach.	5

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	**PO 1**	Interpret the Probability distributions such as Binomial, Poisson and Normal distribution (Understanding) with the support of evaluation of integrals (principles of mathematics) and appreciate their importance and applicability (Apply) in solving complex engineering problems involving uncertainty.	2
	PO 2	Understand the statement and formulation of a complex engineering problem which involves the events of uncertainty, Model it with suitable probability distribution and Apply the concepts of discrete or continuous distributions to develop the solution and reaching substantiated conclusions by the interpretation and validation of results through proper documentation	7
CO 3	**PO 1**	Interpret (Understand) the results of Bivariate and Correlation Analysis by using ratios, square roots, straight lines and planes (principles of mathematics) for statistical forecasting (Apply)in complex engineering problems involving bivariate or multivariate data.	2
CO 4	**PO 1**	Select appropriate statistical methods (understand) for solving some real-time complex engineering problems governed by correlation with the knowledge of fundamental principles of mathematics.	2
	PO 4	Understand the technical uncertainty prevailing in the probabilistic situations with aids of technical literature and quantitatively measure The expected values, variances of the modeled discrete random variables in a systematic approach.	5
CO 5	**PO 1**	Apply tests of hypotheses which involves the role of mathematical tools like statements, sets, ratios and percentages (principles of mathematics) for both large samples and small samples (knowledge) in making decisions over statistical claims that arise in complex engineering problems which requires sampling inspections.	2
	PO 2	Understand the statement and formulation of a complex engineering problem which involves the events of uncertainty, Model it with suitable probability distribution and Apply the concepts of discrete or continuous distributions to develop the solution and reaching substantiated conclusions by the interpretation and validation of results through proper documentation	7
	PO 4	Understand the technical uncertainty prevailing in the probabilistic situations with aids of technical literature and quantitatively measure The expected values, variances of the modeled discrete random variables in a systematic approach.	5

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	**PO 1**	Identify the role of types of statistical hypotheses, types of errors, sampling distributions of means and confidence intervals with the aid of statements and sets, percentages (principles of mathematics) in hypothesis testing of complex engineering problems which requires sampling inspections.	2
	PO 4	Understand the technical uncertainty prevailing in the probabilistic situations with aids of technical literature and quantitatively measure The expected values, variances of the modeled discrete random variables in a systematic approach.	5
	PO 5	Make Use of R software package a in modeling complex Engineering activities which involves computation of confidence intervals, statistical averages and regression analysis, hypothesis testing.	1

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	-	-	45.5	-	-	-	-	-	-	-		-	-	-
CO 2	66.7	70	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.7	-	-	45.5	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.7	70	-	45.5	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.7	-	-	45.5	100	-	-	-	-	-	-		-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - 40 % $<C<$ 60% –Moderate
3 - 60% $\leq$ C $<$ 100% – Substantial /High

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	Tech Talk	✓	Concept video	✓
Assignments	-				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**PROBABILITY AND RANDOM VARIABLES**
	Random variables: Basic definitions, discrete and continuous random variables; Probability distribution: Probability mass function and probability density functions; Mathematical expectation.
MODULE II	**PROBABILITY DISTRIBUTION**
	Binomial distribution; Mean and variances of Binomial distribution, Recurrence formula for the Binomial distribution; Poisson distribution: Poisson distribution as a limiting case of Binomial distribution, mean and variance of Poisson distribution, Recurrence formula for the Poisson distribution; Normal distribution; Mean, Variance, Mode, Median, Characteristics of normal distribution.
MODULE III	**CORRELATION AND REGRESSION**
	Correlation: Karl Pearson's Coefficient of correlation, Computation of correlation coefficient, Rank correlation, Repeated Ranks; Properties of correlation. Regression: Lines of regression, Regression coefficient, Properties of Regression coefficient, Angle between two lines of regression.

MODULE IV	**TEST OF HYPOTHESIS – I**
	Sampling: Definitions of population, Sampling, Parameter of statistics, standard error; Test of significance: Null hypothesis, alternate hypothesis, type I and type II errors, critical region, confidence interval, level of significance. One sided test, two-sided test. Large sample test: Test of significance for single mean, Test of significance for difference between two sample means, Tests of significance single proportion and Test of difference between proportions.
MODULE V	**TEST OF HYPOTHESIS – II**
	Small sample tests: Student t-distribution, its properties: Test of significance difference between sample mean and population mean; difference between means of two small samples. Snedecor's F-distribution and its properties; Test of equality of two population variances Chi-square distribution and it's properties; Chi-square test of goodness of fit.

TEXTBOOKS

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

2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 43rd Edition, 2012.

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1. http://e4uhu.com/down/Applied/9th

2. https://toaz.info/32fa2f50-8490-42cf-9e6a-f50cb7ea9a5b

3. http://www.mathworld.wolfram.com

COURSE WEB PAGE:

https://www.youtube.com/playlist?list=PLzkMouYverAJ1gjLBz4sA5O0ymIi01or6

REFERENCE BOOKS:

1. N. P. Bali, "Engineering Mathematics", Laxmi Publications, 9th Edition, 2016.

2. S. C. Gupta, V. K. Kapoor, "Fundamentals of Mathematical Statistics", S. Chand and Co., 10th Edition, 2000.

3. Richard Arnold Johnson, Irwin Miller and John E. Freund, "Probability and Statistics for Engineers", Prentice Hall, 8th Edition, 2013.

XIX COURSE PLAN:

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

S.No	Topics to be covered	Course outcomes	Reference
OBE DISCUSSION			
1	Identify the types of sampling (random, stratified, systematic, cluster). Identify the misuses of statistics. Student will use appropriate statistical methods to collect, organize, display, and analyze relevant data. Probability & Statistics introduces students to the basic concepts and logic of statistical reasoning and gives the students introductory-level practical ability to choose, generate, and properly interpret appropriate descriptive and inferential methods. Identify the types of data (qualitative, quantitative, discrete, and continuous).		
CONTENT DELIVERY (THEORY)			
2	Probability Basic definitions	CO 1	T2:26.3
3	Probability	CO 1	R2:21.48
4	Axioms of Probability	CO 1	T2:26.6 R2:21.50
5	Conditional Probability	CO 1	T2:26.7 R2:21.51
6	Random Variables	CO 1	T2:26.8
7	Discrete and Continuous random variables	CO 1	T2:26.10
8	Probability distribution	CO 1	T2:26.14 R2:21.55
9	Probability mass function	CO 1	T2:26.15 R2:21.58
10	Probability Density Function	CO 1	T2:26.16 R2:21.61
11	Mathematical Expectation	CO 2	T2:25.12 R2:21.24
12	Binomial Distribution	CO 2	T2:25.16 R2:21.29
13	Mean, Variance and Mode of Binomial Distribution	CO 2	T2:25.14 R2:21.31
14	Expected Frequency of Binomial Distribution	CO 2	T2:25.14 R2:21.33
15	Poisson Distribution	CO 2	R2:21.33
16	Mean, Variance and Mode of Poisson distribution	CO 2	T2:27.2 R2:21.64
17	Expected Frequency of Poisson Distribution	CO 2	T2:27.2
18	Normal distribution – I	CO 2	T2:27.2 R2:21.67

19	Mean and Variance of Normal Distribution	CO 2	T2:27.2
20	Mode and Median of Normal distribution	CO 2	T2:27.3 R2:21.71
21	Normal distribution – II	CO 2	T2:27.4 R2:21.68
22	Correlation	CO 3	T2:27.7 R2:21.74
23	Rank Correlation	CO 3	T2:27.12 R2:21.75
24	Rank Correlation for Repeated Ranks	CO 3	T2:27.8 R2:21.72
25	Regression Lines-I	CO 4	T2:27.8 R2:21.73
26	Regression Lines-II	CO 4	T2:27.14 R2:21.78
27	Regression Lines-III	CO 4	T2:27.19 R2:21.814
28	Sampling distribution – I	CO 5	T2:27.12 R2:21.82
29	Sampling distribution – II	CO 5	T2:27.18 R2:21.82
30	Testing of hypothesis for Large Samples	CO 5	T2:26.15 R2:21.58
31	Test of hypothesis for single mean	CO 5	T2:26.16 R2:21.61
32	Test of hypothesis for difference of means	CO 5	T2:25.14 R2:21.33
33	Test of hypothesis for single proportion	CO 5	R2:21.33
34	Test of hypothesis for difference of proportions	CO 5	T2:27.2 R2:21.64
35	Testing of hypothesis for small samples	CO 6	T2:27.2
36	Student's t-distribution for single mean	CO 6	T2:26.16 R2:21.61
37	Student's t-distribution for difference of means	CO 6	T2:25.12 R2:21.24
38	F-distribution	CO 6	T2:25.16 R2:21.29
39	Chi-Square distribution – I	CO 6	T2:27.14 R2:21.78
40	Chi-Square distribution – II	CO 6	T2:27.19 R2:21.814
41	Chi-Square distribution – III	CO 6	T2:27.12 R2:21.82
PROBLEM SOLVING/ CASE STUDIES			
42	Problems on Probability	CO 1	T2:26.3
43	Problems on Discrete and Continuous random variables	CO 1	R2:21.48

44	Problems on Probability mass function	CO 1	T2:26.6 R2:21.50
45	Problems on Probability density function	CO 1	T2:26.7 R2:21.51
46	Problems on Binomial Distribution	CO 2	T2:26.8
47	Problems on Poisson Distribution	CO 2	T2:26.10
48	Problems on Normal Distribution	CO 2	T2:26.14 R2:21.55
49	Problems on Correlation	CO 3	T2:26.15 R2:21.58
50	Problems on Regression	CO 4	T2:26.16 R2:21.61
51	Problems on Sampling distribution	CO 5	T2:25.12 R2:21.24
52	Problems on Test of hypothesis for single mean and difference of means	CO 5	T2:25.16 R2:21.29
53	Problems on Test of hypothesis for single proportion and difference of proportions	CO 6	T2:25.14 R2:21.31
54	Problems on t-distribution	CO 6	T2:25.14 R2:21.33
55	Problems on F-distribution	CO 6	R2:21.33
56	Problems on Chi-Square distribution	CO 6	T2:27.2 R2:21.64
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Definitions terminology discussion on probability and random variables	CO 1	T2:26.6 R2:21.50
58	Probability and Random variables	CO 2	T2:26.7 R2:21.51
59	Definitions& terminology discussion on correlation and regression.	CO 3, CO 4	T2:25.14 R2:21.33
60	Definitions & terminology discussion on Tests of Hypothesis.	CO 5	R2:21.33
61	Definitions & terminology discussion on Tests of significance.	CO 6	R2:21.33

DISCUSSION OF QUESTION BANK			
62	Question bank discussion on Probability, Random variables and Probability Distributions	CO 1	T2:26.6 R2:21.50
63	Question bank discussion on probability distributions.	CO 2	T2:26.7 R2:21.51
64	Question bank discussion on correlation and regression.	CO 3,CO 4	T2:25.14 R2:21.33
65	Question bank discussion on Tests of Hypothesis.	CO 5	R2:21.33
66	Question bank discussion on Tests of significance.	CO 6	R2:21.33

Course Coordinator: **HOD ME**
Ms. P Naga Lakshmi Devi

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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**SOLID MECHANICS**				
Course Code	AMEC05				
Program	B.Tech				
Semester	Three				
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3		
Course Coordinator	Dr. K. Viswanath Allamraju, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC01	II	Engineering Mechanics

II COURSE OVERVIEW:

This course is designed to provide students an understanding of deformation of solid bodies under external loading, shear force, bending moment diagrams of beams and Euler's column theory. The basis of virtually all mechanical design lies in how the material reacts to outside forces. Mechanics is the core of engineering analysis and is one of the oldest of the physical sciences. An in-depth understanding of material properties as well as how certain materials react to outside stimulus is paramount to an engineering education.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Solid Mechanics	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
50%	Understand
25%	Apply
15 %	Analyze

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

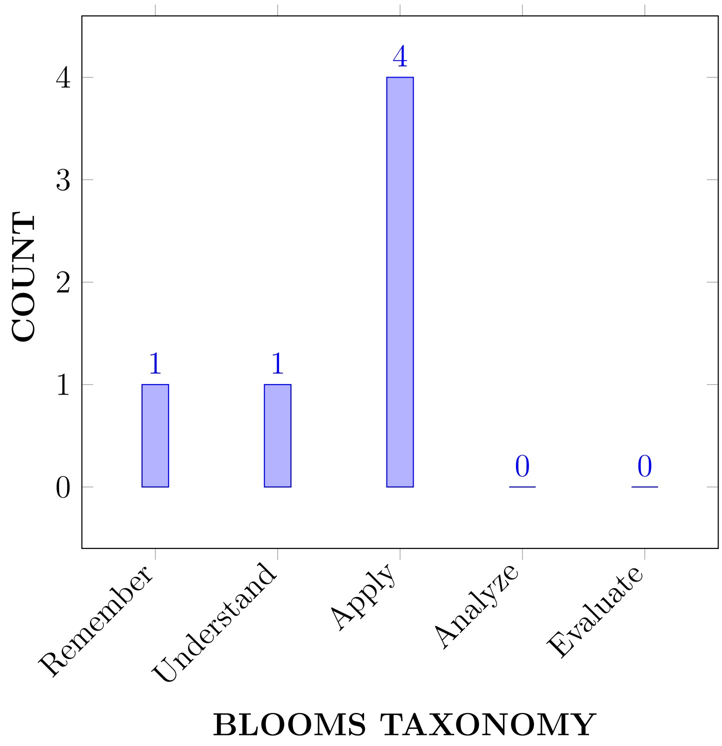
I	The variations of normal and shear stresses, slope and deflections throughout the span and cross section of solids in relation to the applied loads.
II	The concepts of stress analysis, theories of failure, relationship between mechanical and metallurgical properties to design and analyse commonly used machine components.
III	The theory of pure torsion, bending to draw, analyze shear stress distribution diagrams in circular shafts and bending moment distribution diagrams in various cross sections of beams for different loading types.

VII COURSE OUTCOMES:

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

CO 1	**Relate** the concepts of stress and strain at a point as well as the stress-strain relationships for linear, elastic, homogeneous and isotropic materials.	Remember
CO 2	**Summarize** the equilibrium equations for constructing the shear force and bending moment diagrams for different types of loads on cantilever, simply supported and over hanging beams.	Understand
CO 3	**Identify** the principal stresses, maximum shearing stresses and angles acting on any arbitrary plane within a structural element using Mohr's circle method.	Apply
CO 4	**Apply** the knowledge of theories of failure, shear force and bending moment relations for analyzing the flexural stress, shear stress distributions and failure of beam sections.	Apply
CO 5	**Utilize** Maxwell's reciprocal theorem, double integration method and moment area method to determine the maximum and minimum slope and deflections of beams.	Apply
CO 6	**Make use of** the concept of torsion and buckling of thin shells, spheres, etc. to determine the stresses at various points of geometry.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety.	3	CIE/Quiz/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	Assignments/ SEE /CIE, AAT, QUIZ
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	Assignments/ SEE /CIE, AAT, QUIZ
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	3	Research papers / Group discussion / Short term courses
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	3	Research papers / Group discussion / Short term courses

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Apply** the knowledge of mathematics and science to **resolve** normal stresses, strains, maximum shearing stresses and properties in different types of materials such as for linear, elastic, homogeneous and isotropic materials.	2
	PO 2	**Identify, formulate and analyse** the stresses and strains at a point as well as the stress-strain relationships and **examine, interpret and synthesize** the properties of linear, elastic, homogeneous and isotropic materials.	6

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 4	Use research-based **knowledge** including **design** of **experiments**, **analysis** and **interpretation** of data, and **synthesis** of the data to provide valid information **relating** to various Poisson's ratio of different sections and materials.	7
	PO 12	**Recognize** the need for and having the preparation and ability to **engage** in independent and life-long learning in the broadest context of technological change of materials with repect to **estimation** and **innovation** of smart materials.	4
CO 2	PO 1	**Apply** the knowledge of mathematics and science to **resolve** the equilibrium equations for constructing the shear force and bending moment diagrams for different types of loads on cantilever, simply supported and over hanging beams.	2
	PO 2	**Identify, formulate and analyse** the shear force and bending moment at a point as well as the load vs force vs moment relationships and **interpret, synthesize** the properties for various beam sections.	5
	PO 3	**Design** solutions for complex engineering problems and **design system components** or beams that meet the requirement of specified needs with appropriate consideration for the **development** of variety of beam sections with proper **validation** and safety.	5
	PO 4	Use research-based knowledge including **design** of **experiments**, **analysis** and **interpretation** of data to provide valid information **relating** to point of contraflexure of different beam sections and materials.	5
	PO 6	**Apply** reasoning informed by the contextual knowledge to **assess** societal and safety cultural issues and the consequent responsibilities relevant to the professional engineering practice related to beams **analysis**.	3
	PO 12	**Recognize** the need for and having the preparation and ability to **engage** in independent and life-long learning in the broadest context of technological change of materials with repect to **estimation** and **innovation** of smart materials in the production of beams.	4
	PSO 3	**Make use of** computational and experimental tools for building career paths towards **innovation**, startups, employability in the field of structural engineering.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 3	PO 1	**Apply** the knowledge of mathematics and science to **derive** the equations for principal stresses, strains and maximum shearing stresses of an arbitrary element.	2
	PO 2	**Identify, formulate and analyse** the principal stresses, maximum shearing stresses and angles acting on any arbitrary plane within a structural element to **draw** Mohr's circle and **interpret** the data.	5
	PO 6	**Apply** reasoning informed by the contextual knowledge to **assess** societal and safety cultural issues and the consequent responsibilities relevant to the professional engineering practice related to principal stresses of elements and their **analysis**.	3
	PSO 1	**Formulate and evaluate** engineering concepts of principal stresses and strains adopting the Mohr's circle for the resolution of engineering components such as shafts.	2
CO 4	PO 1	**Apply** the knowledge of mathematics and science to **resolve** the equations for various theories of failure to **determine** whether the failure will occur or not.	3
	PO 2	**Identify, formulate and analyse** the shear stress, theories of failure for different structural elements by **drawing** the stress distribution diagrams, **interpret and estimate** the failure of structural members.	6
	PO 3	**Design** solutions for complex engineering problems and **design system components**or beams that meet the requirement of specified needs with appropriate consideration for the **development** of different kinds of failure theories with proper **validation** and **justification**.	6
	PO 4	Use research-based knowledge including **design** of **experiments**, **analysis** and **interpretation** of data to provide **valid** information **relating** to theories of failure to **apply** in structural engineering.	7
	PO 12	**Recognize** the need for and having the preparation and ability to **engage** in independent and life-long learning in the broadest context of technological change of materials with repect to **estimation** and **innovation** of smart materials in the production structural members.	4
	PSO 3	**Make use of** computational and experimental tools for building career paths towards **innovation**, startups, employability in the field of structural engineering.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 5	PO 1	**Apply** the knowledge of science and engineering fundamentals to **determine** the maximum and minimum slope and deflections of beams using Maxwell's reciprocal theorem, double integration method and moment area method.	2
	PO 2	**Identify, formulate and analyse** slope, deflections of beams utilizing Maxwell's reciprocal theorem, double integration method, moment area methods to **interpret and estimate** the characteristics of a beam.	5
	PO 12	**Recognize** the need for and having the preparation and ability to **engage** in independent and life-long learning in the broadest context of technological change of materials with repect to **estimation** and **innovation** in the design, development of beams from the slope and deflection point of view.	4
	PSO 1	**Formulate** and **evaluate** engineering concepts of Maxwell's reciprocal theorem, double integration method, moment area methods for the resolution of engineering components such as beams.	2
CO 6	PO 1	**Apply** the knowledge of mathematics and science to **resolve** the angle of twist, shear stress, etc. relating to Hooke's law to **draw** shear stress distribution within a circular shaft.	3
	PO 2	Use research based knowledge, **identify, formulate and analyse** the data relating to pure torsion, to **draw** shear stress distribution within a circular shaft and **interpret, estimate** the properties of different shaft materials.	6
	PO 3	**Design** solutions for complex engineering problems and **design system components**or shafts to **achieve** the requirement of specified needs with appropriate consideration for the **development** of different kinds of shafts and springs with proper **validation** and **justification**.	6
	PO 4	Use research-based knowledge including **design** of **experiments**, **analysis** and **interpretation** of data to provide **valid** information **relating** to shafts, springs and to **derive** equivalent expression for columns.	7
	PSO 1	**Formulate and evaluate** engineering concepts of torsion in design of engineering components such as shafts.	2
	PSO 3	**Make use of** computational and experimental tools for building career paths towards **innovation**, startups, employability in the field of structural engineering.	2

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	60	-	63.6	-	-	-	-	-	-	-	50	-	-	-
CO 2	66.7	50	50	45	-	60	-	-	-	-	-	50	-	-	100
CO 3	66.7	50	-	-	-	60	-	-	-	-	-	-	100	-	-
CO 4	100	60	60	63.6	-	-	-	-	-	-	-	50	-	-	100
CO 5	66.7	50	-	-	-	-	-	-	-	-	-	50	100	-	-
CO 6	100	60	60	63.6	-	-	-	-	-	-	-	-	100	-	100

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	-	3	-	-	-	-	-	-	-	2	-	-	-
CO 2	3	2	2	2	-	2	-	-	-	-	-	2	-	-	3
CO 3	3	2	-	-	-	2	-	-	-	-	-	-	3	-	-
CO 4	3	3	3	3	-	-	-	-	-	-	-	2	-	-	3
CO 5	3	2	-	-	-	-	-	-	-	-	-	2	3	-	-
CO 6	3	3	3	3	-	-	-	-	-	-	-	-	3	-	3
TOTAL	18	15	8	11	-	4	-	-	-	-	-	8	9	-	9
AVERAGE	3	2.5	2.6	2.75	-	2	-	-	-	-	-	2	3	-	3

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Tech talk	✓
Assignments	-				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**SIMPLE STRESSES AND STRAINS**
	Elasticity and plasticity, types of stresses and strains, Hooke's law, stress and strain diagram for mild steel, working stress, factor of safety, lateral strain, Poisson's ratio and volumetric strain, elastic moduli and the relationship between them, bars of varying section, composite bars, temperature stresses.
MODULE II	**SHEAR FORCE AND BENDING MOMENT DIAGRAMS**
	Definition of beam, types of beams, concept of shear force and bending moment, S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, U.D.L., U.V.L. and combination of these loads – point of contra flexure, relation between S.F., B.M, and rate of loading at a section of a beam.
MODULE III	**PRINCIPAL STRESSES**
	Principle stresses and strains-computation of principal stresses and strains on inclined planes: Uni-axial problems, Bi axial problems, Mohr's circle: Uni axial problems, Bi axial problems. THEORY OF FAILURES- Minimum principle stress, strain, shear stress and strain energy theories.
MODULE IV	**FLEXURAL STRESSES, DEFLECTION OF BEAMS**
	Beams and types transverse loading on beams shear force and bend moment diagrams types of beam supports, simply supported and over-hanging beams, cantilevers. Theory of bending of beams, bending stress distribution and neutral axis, shear stress distribution, point and distributed loads. Moment of inertia about an axis and polar moment of inertia, deflection of a beam using double integration method, computation of slopes and deflection in beams, Maxwell's reciprocal theorems.
MODULE V	**TORSION, SPRING, STRESSES IN THIN SHELLS AND COLUMNS**
	Theory of pure torsion, derivation of torsion equations $T/J = q/r = G\Theta/L$, assumptions made in the theory of pure torsion, torsional moment of resistance, polar section modulus, introduction to springs: deflection of springs, thin cylinders, thin seamless cylindrical shells, derivation of formula for longitudinal and circumferential stresses, hoop stress, longitudinal and volumetric strains, changes in diameter, and volume of thin cylinders, thin spherical shells, and efficiency of a joint, Euler's column theory.

TEXTBOOKS

1. R.Subramaniam, "The Strength of Materials", Oxford publishers, 4th Edition, 2018.
2. S. Ramamrutam, "Strength of Materials", Dhanpat Rai Publishing Company, 18th Edition, 2014.

REFERENCE BOOKS:

1. Robert J Asaro, Vlado Lubarda, "Mechanics of Solids and Materials", Cambridge University Press, 4th Edition, 2006.
2. Vazirani, Ratwani, "Analysis of Structures", Khanna Publishers, 19th Edition, 2014.

WEB REFERENCES:

1. http://www.efunda.com/sm home/sm.cfm
2. https://nptel.ac.in/courses/112105171/1

COURSE WEB PAGE:

https://www.iare.ac.in/sites/default/files/UG20/SolidMechanics.pdf

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Introduction to Outcome Based Education		
CONTENT DELIVERY (THEORY)			
2	Elasticity and plasticity	CO 1	T2:2.3
3	Types of stresses and strains, Hooke's law	CO 1	R1:2.6
4	Stress - strain diagram for mild steel	CO 2	T1:2.6
5-6	Working stress, factor of safety, lateral strain,	CO 2	T2:2.7 R1:2.18
7-8	Poisson's ratio and volumetric strain,	CO 2	T2:2.22
9-10	Elastic moduli and the relationship between them,	CO 2	T2:2.25
11	Bars of varying section, composite bars, temperature stresses.	CO 2	T3:3.6.7
12	Definition of beam, types of beams.	CO 1	T2:2.22
13-14	concept of shear force and bending moment, S.F and B.M diagrams for cantilever	CO 1	T2:2.2
15-17	Simply supported beam subjected to point loads, U.D.L., U.V.L. and combination of these loads	CO 1	T2:2.26 R1:2.55
18-19	Overhanging beams subjected to point loads, U.D.L., U.V.L. and combination of these loads	CO 1	T3:4.162
20-22	Point of contra flexure, relation between S.F., B.M, and rate of loading at a section of a beam.	CO 1	T3:4.162
23	Principle stresses and strains	CO 4	T2:3.14 R1:4.33

24-25	Computation of principal stresses and strains on inclined planes.	CO 4	R1:4.36
26	Uni-axial problems	CO 4	T2:3.18 R1:4.64
27	Bi axial problems	CO 4	T2:3.22
28-29	Mohr's circle: Uni axial problems, Bi axial problems.	CO 5	T2:3.28 R1:4.67
30	THEORY OF FAILURES- Minimum principle stress,	CO 5	T2:4.2
31-33	Strain, shear stress and strain energy theories.	CO 5	T2:4.3 R1:4.71
34	Beams and types transverse loading on beams	CO 5	T1:4.8 R2:4.68
35	shear force and bend moment diagrams	CO 5	T2:4.15 R1:5.74
36	Types of beam supports, simply supported and over-hanging beams, cantilevers.	CO 6	T1:4.12 R2:5.75
37	Theory of bending of beams.	CO 5	T1:4.8 R1:5.72
38-39	Bending stress distribution and neutral axis.	CO 6	T1:5.8 R1:5.73
40	shear stress distribution,	CO 6	T1:5.14 R1:6.78
41	Point and distributed loads.	CO 5	T2:5.19 R1:6.81
42	Moment of inertia about an axis and polar moment of inertia,	CO 6	T1:6.4 R2:6.8
43	Deflection of a beam using double integration method,	CO 6	T2:7.7 R1:7.74
44	Computation of slopes and deflection in beams and Maxwell's reciprocal theorems.	CO 6	T1:7.12 R2:8.75
45	Theory of pure torsion, derivation of torsion equations $T/J = q/r = G\Theta/L$,	CO 6	T1:7.8 R1:8.72
46	Assumptions made in the theory of pure torsion, torsional moment of resistance, polar section modulus	CO 6	T1:8.8 R1:8.73
47	Introduction to springs: deflection of springs.	CO 6	T1:9.14 R1:10.78
48	Thin cylinders, thin seamless cylindrical shells.	CO 6	T2:9.19 R1:10.814
49	Derivation of formula for longitudinal and circumferential stresses.	CO 6	T1:10.4
50-52	Hoop stress, longitudinal and volumetric strains, changes in diameter, and volume of thin cylinders,	CO 6	T2:10.7 R1:12.74
53	Thin spherical shells, and efficiency of a joint.	CO 6	T1:11.12 R2:12.75
54-55	Euler's column theory.	CO 6	T1:12.4
PROBLEM SOLVING/ CASE STUDIES			
1	Stress - strain diagram for mild steel	CO 2	T1:2.6

2	Working stress, factor of safety, lateral strain,	CO 2	T2:2.7 R1:2.18
3	Poisson's ratio and volumetric strain,	CO 2	T2:2.22
4	Bars of varying section, composite bars, temperature stresses.	CO 2	T3:3.6.7
5	Simply supported beam subjected to point loads, U.D.L., U.V.L. and combination of these loads	CO 1	T2:2.26 R1:2.55
6	Overhanging beams subjected to point loads, U.D.L., U.V.L. and combination of these loads	CO 1	T3:4.162
7	Point of contra flexure, relation between S.F., B.M, and rate of loading at a section of a beam.	CO 1	T3:4.162
8	Computation of principal stresses and strains on inclined planes.	CO 4	R1:4.36
9	Uni-axial problems	CO 4	T2:3.18 R1:4.64
10	Bi axial problems	CO 4	T2:3.22
11	Mohr's circle: Uni axial problems, Bi axial problems.	CO 5	T2:3.28 R1:4.67
12	shear stress distribution,	CO 6	T1:5.14 R1:6.78
13	Computation of slopes and deflection in beams and Maxwell's reciprocal theorems.	CO 6	T1:7.12 R2:8.75
14	Thin cylinders, thin seamless cylindrical shells.	CO 6	T2:9.19 R1:10.814
15	Hoop stress, longitudinal and volumetric strains, changes in diameter, and volume of thin cylinders,	CO 6	T2:10.7 R1:12.74
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Module I: Simple stresses and strains	CO 1	T2:2.3
2	Module II: Shear force and Bending moment	CO 2, CO 3	T2:3.14 R1:4.33
3	Module III:Principal stresses and strains	CO 4	T2:4.2 R1:5.72
4	Module IV:Flexural stresses	CO 5	T2:7.7 R1:7.74
5	Module V:Torsion and Springs	CO 6	T2:9.19 R1:10.814
DISCUSSION OF QUESTION BANK			
1	Module I: Simple stresses and strains	CO 1	T2:2.3
2	Module II: Shear force and Bending moment	CO 2, CO 3	T2:3.14 R1:4.33

3	Module III:Principal stresses and strains	CO 4	T2:4.2 R1:5.72
4	Module IV:Flexural stresses	CO 5	T2:7.7 R1:7.74
5	Module V:Torsion and Springs	CO 6	T2:9.19 R1:10.814

Signature of Course Coordinator **HOD, ME**

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

MECHANICALL ENGINEERING

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**THERMODYNAMICS**				
Course Code	AMEC06				
Program	B.Tech				
Semester	III				
Course Type	CORE				
Regulation	UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	0	0
Course Coordinator	Dr. Pravat Ranjan Pati, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSC02	I	Linear Algebra and Calculus
B.Tech	AHSB04	I	Waves And Optics

II COURSE OVERVIEW:

Thermodynamics is the science that deals with the relationship between heat and work and those properties of systems that bear relation to heat and work. General laws of energy transformations concerning all types of systems, mechanical, electrical and chemical may fall within the purview of this science. It is a science based on a number of empirical laws formed by experimentation from which all predictions concerning the physical behavior of the system may be deduced by logical reasoning. The findings have been formalized into the various laws of thermodynamics. The power cycles and refrigeration cycle based on thermodynamic system is studied. The students are familiarizing with standard charts and tables.

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
16%	Remember
50 %	Understand
33 %	Apply
0 %	Analyze
0 %	Evaluate

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

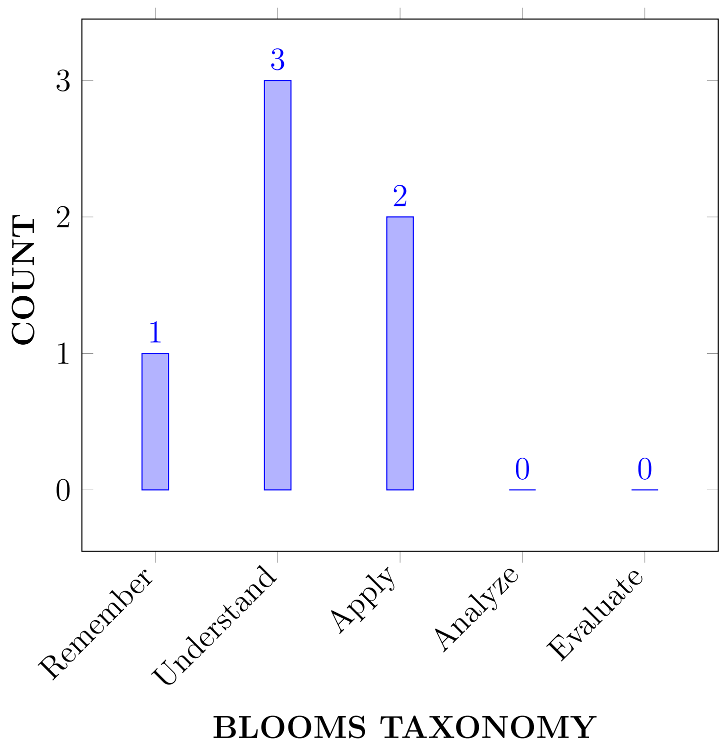
I	The fundamental knowledge on concepts of physics and chemistry for obtaining the axiomatic principles using thermodynamic co-ordinates.
II	The thermodynamic disorderness in the real time physical systems like external/internal heat engines, heat pumps to get the measure of performance characteristics.
III	The performance characteristics of open and closed systems of thermodynamic cycles for effective delineation of real time applications.
IV	The thermodynamic cycles such as power and refrigerant cycles to yield alternative solutions to conserve the environment.

VII COURSE OUTCOMES:

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

CO 1	**Recall** the basic concepts of thermodynamic properties and working principles of energy conversions in physical systems by laws of thermodynamics.	Remember
CO 2	**Summarize** the equivalence of two statements of second law of thermodynamics and the entropy concepts for typical engineering problems.	Understand
CO 3	**Explain** the properties of pure substances and steam to emit relevant inlet and exit conditions of thermodynamic work bearing systems.	Understand
CO 4	**Apply** the significance of partial pressure and temperature to table the performance parameters of ideal gas mixtures.	Apply
CO 5	**Identify** the properties of air conditioning systems by practicing psychrometry chart and property tables.	Apply
CO 6	**Illustrate** the working of various air standard cycles and work out to get the performance characteristics.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2.6	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/Quiz/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions	3	CIE/Quiz/AAT
PO 6	**The engineer and society:**Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice	1	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	2.8	AAT

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH POs, PSOs:

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

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Recall the thermodynamic properties and working principles of energy conversions in physical systems by fundamental laws of thermodynamics using the **knowledge of engineering fundamentals, science and mathematics**.	3
	PO 4	Explain the thermodynamic properties and working principles of **energy** conversions in physical systems using **research-based knowledge** and research methods including **design of experiments**, **analysis** and **interpretation of data**, and **synthesis** of the information to provide valid **conclusions**.	7
	PO 6	Apply the working principles of energy conversions in physical systems to assess societal, health, safety, legal and cultural issues and the **consequent responsibilities** relevant to the professional **engineering practice**.	2
	PSO 2	Formulate and Evaluate the thermodynamic properties using the concepts of **Thermo-Fluid Systems** to provide solutions for **Inter Disciplinary Engineering Applications**.	2

CO 2	PO 1	Recall the various statements of second law of thermodynamics and the properties applied to various thermodynamic systems using **(engineering fundamentals and science)** and derive the relationship between them using basic **(mathematical equations).**	3
	PO 2	Identify and **formulate** the statements of second law of **thermodynamics** using **first principles** of **mathematics**, **natural sciences**, and **engineering sciences**.	6
	PSO 2	Formulate and Evaluate the equivalence of two statements of second law of thermodynamics and the entropy principle using the concepts of **Thermo-Fluid Systems** to provide solutions for **Inter Disciplinary Engineering Applications**.	2
CO 3	PO 1	Interpret the properties of pure substances and steam using fundamental **knowledge of science and engineering** to evolve relationships using partial derivative **mathematical functions**.	3
	PO 3	Explain the solutions for complex Engineering problems and identify the properties of pure substances and steam to emit relevant inlet and exit conditions of thermodynamic **systems** used for the **public health**, **society**, and **environment**.	4
	PSO 2	Formulate and Evaluate the properties of pure substances and steam using the concepts of **Thermo-Fluid Systems** to provide solutions for **Inter Disciplinary Engineering Applications**.	2
CO 4	PO 1	Show the significance of partial pressure and temperature using **fundamental engineering and science** to table the performance parameters of gaseous mixtures in **mathematical form**.	3
	PO 2	Identify and **formulate** the significance of partial pressure and temperature of ideal gas mixtures using first principles of **mathematics**, **natural sciences**, and **engineering sciences**.	4
	PO 3	Explain the solutions for **complex problems** and identify the significance of partial pressure and temperature of ideal gas mixtures used for the **public health**, **society**, and **environment**.	4
CO 5	PO 1	Understand the significance of psychrometry charts and Mollier diagram to determine the properties of air conditioning systems using the (**fundamentals of engineering, science and mathematical equations**).	3

	PO 3	Explain the solutions for **complex problems** and identify the the properties of air conditioning systems used for the **public health**, **society**, and **environment**.	4
	PSO 2	Evaluate the properties of air conditioning systems using the concepts of **Thermo-Fluid Systems** to provide solutions for Inter Disciplinary Engineering Applications.	1
CO 6	PO 1	Evaluate the performance characteristics of various air standard cycles using the basic understanding of **engineering science, knowledge and mathematical equations.**	3
	PO 2	Identify and **formulate** the performance characteristics of various **air standard cycles** using **first principles** of **mathematics**, **natural sciences**, and **engineering sciences**.	6
	PO 4	Explain the the performance characteristics of various **air standard cycles** using **research-based knowledge** and research methods including **design of experiments**, **analysis** and **interpretation of data**, and **synthesis** of the information to provide valid **conclusions**.	7
	PSO 2	Evaluate the properties of various air standard cycles using the concepts of **Thermo-Fluid Systems** to provide solutions for **Inter Disciplinary Engineering Applications**.	2

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

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	63	-	40	-	-	-	-	-		-	100	-
CO 2	100	60	-	-	-	-	-	-	-	-	-	-	-	100	-
CO 3	100	-	40	-	-	-	-	-	-	-	-	-	-	100	-
CO 4	100	40	40	-	-	-	-	-	-	-	-		-	-	-
CO 5	100	-	40	-	-	-	-	-	-	-	-	-	-	50	-
CO 6	100	60	-	63	-	-	-	-	-	-	-		-	100	-

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	3	-	2	-	-	-	-	-		-	3	-
CO 2	3	3	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 3	3	-	2	-	-	-	-	-	-	-	-	-	-	3	-
CO 4	3	2	2	-	-	-	-	-	-	-	-		-	-	-
CO 5	3	-	2	-	-	-	-	-	-	-	-	-	-	2	-
CO 6	3	3	-	3	-	-	-	-	-	-	-		-	3	-
TOTAL	18	8	6	6	-	2	-	-	-	-	-	-	-	14	-
AVERAGE	3	2.6	2	3	-	1	-	-	-	-	-	-	-	2.8	-

XVI ASSESSMENT METHODOLOGY DIRECT:

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

XVII ASSESSMENT METHODOLOGY INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**BASIC CONCEPTS AND FIRST LAW OF THERMODYNAMICS**
	System, control volume, surrounding, boundaries, universe, types of systems, macroscopic and microscopic viewpoints, concept of continuum, thermodynamic equilibrium, state, property, process, cycle, reversibility, quasistatic process, irreversible process, causes of irreversibility, various flow and non-flow processes, energy in state and in transition, types-work and heat, point and path function, Zeroth law of thermodynamics, concept of quality of temperature, Principles of thermometry, reference points, constant volume gas thermometer, ideal gas scale, Joule's experiment, first law of thermodynamics, PMM1, corollaries first law applied to a process, applied to a flow system, steady flow energy equation.
MODULE II	**SECOND LAW OF THERMODYNAMICS**
	Thermal reservoir, heat engine, heat pump, parameters of performance, second Law of thermodynamics, Kelvin Planck and Claussius statements and their equivalence, Corollaries, PMM of second kind, Carnot's principle, Carnot cycle and its specialties, thermodynamic scale of temperature, Claussius inequality, Entropy, principle of Entropy increase, availability and irreversibility, thermodynamic potentials, Gibbs and Helmholtz functions, Maxwell relations, elementary treatment of the Third Law of thermodynamics.
MODULE III	**PURE SUBSTANCES AND GAS LAWS**
	Phase transformations, T-S and H-S diagrams, P-V-T surfaces, triple point at critical state properties during change of phase, dryness fraction, Mollier charts, various thermodynamic processes and energy transfer, steam calorimeter. Gas Laws: Equation of state, specific and universal gas constants, throttling and free expansion processes, Vander Waals equation.
MODULE IV	**MIXTURES OF PERFECT GASES**
	Mole fraction, mass friction, gravimetric and volumetric analysis, volume fraction, Dalton's law of partial pressure, Avogadro's laws of additive volumes, and partial pressure, equivalent gas constant, internal energy, enthalpy, specific heats and entropy of mixture of perfect gases; psychometric properties, dry bulb temperature, wet bulb temperature, dew point temperature, thermodynamic wet bulb temperature, specific humidity, relative humidity, saturated air, vapor pressure, degree of saturation, adiabatic saturation, Carrier's equation, Psychometric chart.
MODULE V	**POWER CYCLES**
	Otto, Diesel, Dual combustion cycles, description and representation on P-V and T-S diagram, thermal efficiency, mean effective pressures on air standard basis, comparison of cycles.

TEXTBOOKS

1. P. K. Nag, "Engineering Thermodynamics", Tata McGraw Hill, 6th Edition, 2017.
2. Yunus Cengel, Michael A. Boles, "Thermodynamics-An Engineering Approach", Tata McGraw Hill, 8th Edition, 2017

REFERENCE BOOKS:

1. J. B. Jones, R. E. Dugan, "Engineering Thermodynamics", Prentice Hall of India Learning, 1st Edition, 2009.
2. Y. V. C. Rao, "An Introduction to Thermodynamics", Universities Press, 3rd Edition, 2013
3. K. Ramakrishna, "Engineering Thermodynamics", Anuradha Publishers, 2nd Edition, 2011
4. J.P. Holman, "Thermodynamics", Tata McGraw Hill, 4thEdition, 2013.

WEB REFERENCES:

1. https://nptel.ac.in/courses/101104063
2. https://nptel.ac.in/courses/127106135
3. https://nptel.ac.in/courses/112108148

COURSE WEB PAGE:

https://www.iare.ac.in/sites/default/files/UG20/Thermodynamics.pdf

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Introduction to outcome based education		
CONTENT DELIVERY (THEORY)			
2	System, control volume, surrounding, boundaries, universe, types of systems.	CO1	T2:2.3
3	Macroscopic and microscopic viewpoints, concept of continuum,	CO1	R1:2.6
4	Thermodynamic equilibrium, state, property, process, cycle, reversibility.	CO1	T1:2.6
5	Quasi static process, irreversible process, causes of irreversibility.	CO1	T2:2.7 R1:2.18
6	Various flow and non-flow processes ,energy in state and in transition, types-work	CO1	T2:2.22

7	Heat, point and path function, Zeroth law of thermodynamics.	CO1	T2:2.25
8	Concept of quality of temperature, Principles of thermometry, reference points.	CO1	T2:2.26 R1:2.55
9	Constant volume gas thermometer, ideal gas scale, PMMI Joule‘s experiments,	CO1	T2:2.16 R1:2.61
10	First law of thermodynamics, corollaries first law applied to a process	CO1	T2:2.30 R1:2.58
11	Applied to a flow system, steady flow energy equation.	CO1	T2:3.6 R1:4.29
12	Thermal reservoir, heat engine, heat pump	CO2	T2:3.14 R1:4.31
13	Parameters of performance, second Law of thermodynamics	CO2	T2:3.14 R1:4.33
14	Kelvin Planck, Claussius statements and their equivalence	CO2	R1:4.36
15	Corollaries, PMM of second kind, Carnot‘s principle	CO2	T2:3.18 R1:4.64
16	Carnot cycle and its specialties	CO2	T2:3.22
17	Thermodynamic scale of temperature, Claussius inequality	CO2	T2:3.28 R1:4.67
18	Entropy, principle of Entropy increase, availability and irreversibility	CO2	T2:4.2
19	Thermodynamic potentials	CO2	T2:4.3 R1:4.71
20	Gibbs and Helmholtz functions, Maxwell relations	CO2	R2:4.68
21-22	Elementary treatment of the Third Law of thermodynamics	CO2	T2:4.15 R1:5.74
23	Phase transformations, T-S and H-S diagrams, P-V-T surfaces,	CO3	T1:4.12 R2:5.75
24-25	Triple point at critical state properties during change of phase,	CO3	T1:4.8 R1:5.72
26	Dryness fraction, Mollier charts, various thermodynamic processes	CO3	T1:5.8 R1:5.73
27-28	Energy transfer, steam calorimeter.	CO3	T1:5.14 R1:6.78
29	Equation of state, specific and universal gas constants.	CO4	T2:5.19 R1:6.81
30-31	Throttling and free expansion processes	CO4	T1:6.4 R2:6.8
32	Deviations from perfect gas model, Vander Waals equation of state.	CO4	T2:7.7 R1:7.74
33-34	Mole fraction, mass friction, gravimetric and volumetric analysis, volume fraction,	CO4	T1:7.12 R2:8.75

35	Dalton's law of partial pressure, Avogadro's laws of additive volumes, and partial pressure	CO4	T1:7.8 R1:8.72
36	Equivalent gas constant, internal energy, enthalpy, specific heats	CO4	T1:8.8 R1:8.73
37	Entropy of mixture of perfect gases; psychometric properties	CO4	T1:9.14 R1:10.78
38-39	Dry bulb temperature, wet bulb temperature, dew point temperature,	CO5	T2:9.19 R1:10.814
40-41	Thermodynamic wet bulb temperature, specific humidity, relative humidity, saturated air.	CO5	T1:10.4 R2:11.68
42-44	Vapor pressure, degree of saturation, adiabatic saturation,Carrier's equation, Psychometric chart.	CO5	T2:10.7 R1:12.74
45-49	Otto, Diesel, Dual combustion cycles, Problems on cycles	CO6	T1:11.12 R2:12.75
50-51	Description and representation on P-V and T-S diagram,	CO6	T1:12.4 R2:13.68
52-59	Thermal efficiency, mean effective pressures on air standard basis. Comparison of cycles	CO6	T2:13.7 R1:14.74
PROBLEM SOLVING/ CASE STUDIES			
60	When a stationary mass of gas was compressed without friction at constant pressure, its initial state of 0.4m3 and 0.105MPa was found to change to final state of 0.20m3 and 0.105MPa. There was a transfer of 42.5kJ of heat from the gas during the process. Find the change in internal energy of the gas.	CO 1	T2:2.30 R1:2.58
61	Two thermometers one centigrade and other Fahrenheit are immersed in a fluid, after the thermometers reached equilibrium with the fluid, it is noted that both the thermometers indicate the same numerical values. Find the identical numerical values shown by the thermometers. Determine the corresponding temperature of the fluid, express in degrees Kelvin and degrees Rankine.	CO 1	T2:2.26 R1:2.55
62	A piston cylinder device operates 1kg of fluid at 20atm pressure with initial volume is 0.04m3 . Fluid is allowed to expand reversibly following pV 1 .45=C. So that the volume becomes double. The fluid is cooled at constant pressure until the piston comes back. What is the work done in each process?	CO 1	T2:2.22
63	A reversible heat engine is supplied with heat from two constant temperature sources at 900K and 600 K and rejects heat to a constant temperature at 300K to sink. The engine develops work equivalent to 91kJ/s and rejects heat at the rate of 56kJ/sec. Calculate (i) heat supplied by each source (ii) Thermal efficiency of engine.	CO 2	T2:3.14 R1:4.31

64	Three Carnot engine are arranged in series. The first engine takes 4000kJ of heat from a source at 2000K and delivers 1800kJ of work. The second and third engines deliver 1200kJ and 500kJ ofwork respectively. Compare the exhaust temperature of second and third Carnot engines?	CO 2	T2:3.22
65	Two bodies of equal capacities C and T1 and T2 from an adiabatically closed system. Determine the final temperature, if the system is brought to an equilibrium state. i) Freely, ii) reversibly, Proceed to find the maximum work which can be obtained from the system.	CO 2	T2:3.14 R1:4.33
66	Saturated steam has entropy of 6.76 kJ/kg K. Interpret the pressure, temperature, specific volume, enthalpy from Mollier chart.	CO 3	T1:5.8 R1:5.73
67	At a temperature of 423K, 1kg of nitrogen occupies volume of 200 liters. The gas undergoes constant expansion with fully resisted to a volume of 360 liters. Then the gas expanded isothermally to a volume of 500 liters. Sketch the process on p-V and T-S diagram. Find out overall change in entropy.	CO 4	T1:5.14 R1:6.78
68	Solve that for an ideal gas the slope of the constant volume line on the T-S diagram is more than that of the constant pressure line.	CO 4	T2:5.19 R1:6.81
69	Find the relative humidity and specific humidity for air at 30°C and having dew point temperature of 15°C. Show the process.	CO 5	T1:10.4 R2:11.68
70	A mixture of hydrogen and oxygen is to be made, so that the ratio of H2 to O2 is 2—1 by volume. If the pressure and temperature are 1bar and 25°C, respectively. Find the mass of oxygen required and volume of the container.	CO 5	T1:7.12 R2:8.75
71	An air water vapor mixture enters an adiabatic saturator at 30°C and leaves at20°C, which is the adiabatic saturation temperature? The pressure remains constant at 100kPa. Determine the relative humidity and humidity ratio of the inlet mixture.	CO 5	T1:10.4 R2:11.68
72	Calcualte an expression for the air standard efficiency on a volume basis of an engine working on the Otto cycle and represent the processes on p-V and T-S diagrams.	CO 6	T1:11.12 R2:12.75
73	Calculate an expression for air standard efficiency of diesel cycle.	CO 6	T1:11.12 R2:12.75
74	Calculate an expression for air standard efficiency of dual cycle.	CO 6	T1:11.12 R2:12.75

DISCUSSION OF DEFINITION AND TERMINOLOGY			
75	System, surroundings, boundary, thermodynamic equilibrium, process, PMM1, state extensive property, Zeroth law of thermodynamics	CO 1	T2:2.1
76	Reversible and Irreversible Processes, Second law of thermodynamics, enthalpy, entropy, Availability, Carnot Cycle, Carnot Heat Engine, PMM2, Entropy, Refrigerator, Heat pump	CO 2	T2:3.1
77	Ideal gas, pure substance , p-V-T surface, dryness fraction, steam tables vanderwall's equation	CO 3,4	T1:5.1
78	psychrometric chart, WBT and DBT, humidity ratio, relative humidity, absolute humidity, degree of saturation, adiabatic saturation	CO 5	T1:7.1
79	Otto, Diesel, Dual combustion cycles, Brayton cycle, air standard efficiency	CO 6	T1: 11.12
DISCUSSION OF QUESTION BANK			
80	Module I: Basic Concepts and First Law of Thermodynamics	CO 1	T2:2.1
81	Module II: Second Law of Thermodynamics	CO 2	T2:3.1
82	Module III: Pure Substances and Gas Laws	CO 3,4	T1:5.1
83	Module IV: Mixtures of Perfect Gases	CO 5	T1:7.1
84	Module V: Power Cycles	CO 6	T1: 11.12

Signature of Course Coordinator **HOD, ME**
Dr. Pravat Ranjan Pati, Assistant Professor

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

Department	**MECHANICAL ENGINEERING**				
Course Title	**MATERIALS ENGINEERING**				
Course Code	AMEC07				
Program	B Tech				
Semester	III				
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr CH. Sandeep, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSCO3	I	Engineering Physics
B.Tech	AHSCO6	II	Chemistry

II COURSE OVERVIEW:

Materials engineering is a broad multidisciplinary approach to understand the fundamentals of crystallography, microstructures and relation to properties of materials. This course provides key information on phase diagrams, heat treatment, physical and chemical behavior of metallic elements, inter-metallic compounds. Thus there is great relevance for this course in modeling the mechanical, aeronautical and civil structures with ceramics, glasses, polymers and composites as present day designs are based on many advanced materials.

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
15%	Remember
35 %	Understand
50 %	Apply
0 %	Analyze
0 %	Evaluate

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

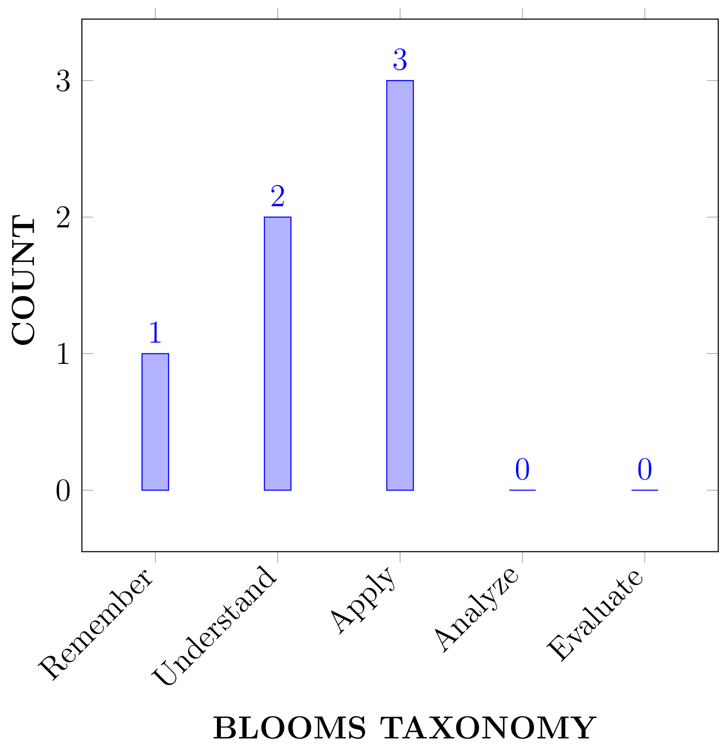
I	The fundamental knowledge of crystallography and phase diagrams under various chemical compositions of ferrous and non ferrous metals.
II	The mechanical behavior of materials, phase diagram, heat treatment, failure of materials and applications with recent materials..
III	The mathematical modeling of determinant structures to present a wealth of real world engineering examples how material science is useful in engineering practices.

VII COURSE OUTCOMES:

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

CO 1	**Recall** the concepts of basic crystallography and imperfections of various crystals for improving the performance of materials.	Remember
CO 2	**Identify** the atomic packing factor of unit cells of various crystal structures to study the properties of materials.	Apply
CO 3	**Choose** the percentage of chemical composition of various materials to determine the proportions and identity of the major oxides of materials.	Apply
CO 4	**Explain** the concept of phase diagram and the basic terminologies associated with metallurgy to construction and identify the phase diagrams and reactions.	Understand
CO 5	**Experiment with** the structure of materials at different levels of crystalline materials for calculating atomic packing factor and co-ordination number.	Apply
CO 6	**Explain** features and classification of newer class material for better performance at lower cost, and less dependence on imports of strategic and critical materials.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VI PROGRAM OUTCOMES:

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

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

VIII. HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

IX. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and **Research** towards **Digital manufacturing** in Product development using Additive manufacturing, **Computer Numerical Control (CNC)** simulation and high-speed machining.	1	SEE/CIA

3 = High; 2 = Medium; 1 = Low

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

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

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Recall the concepts of basic crystallography and imperfections of various crystals for improving the performance of materials using **scientific principles and engineering fundamentals.**	2
	PO 2	Identify the atomic packing factor of unit cells and **formulate** various crystal structures to study the properties of materials to solve **engineering problems**	2
CO 2	PO 1	Apply the **engineering knowledge** to classify the different types of materials to calculate **complex engineering problems.**	2
	PO 2	Understand the given **problem statement and apply data validation techniques to solve** (complex) specific engineering problems related to design.	3
CO 3	PO 3	Identify different types of **boundary conditions** to design the system components applied to heat exchangers for the **environmental considerations.**	2

CO 4	PO 2	**Formulate** the percentage of chemical composition of various materials to determine the proportions and **identity** the major oxides of materials using principles of **engineering sciences.**	3
	PSO 1	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 5	PO 2	Identify the principles associated with the structure of materials to **formulate** and calculate the different levels of crystalline materials for calculating atomic packing factor and co-ordination number **using principles of mathematics, Design and engineering sciences.**	4
CO 6	PO 2	Explain features and classification of newer class material for better performance at lower cost, and less dependence on imports of strategic and critical materials using **mathematical process and natural sciences.**	2

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

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	66.7	20.0													
CO 2	66.7	30.0													
CO 3	0.0	20.0													
CO 4		20.0											100		
CO 5		40.0													
CO 6		20.0													

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

2 - 40 % $< C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	1													
CO 2	3	1													
CO 3			1												
CO 4		1											3		
CO 5		2													
CO 6		1													
TOTAL	6	6	1										3		
AVERAGE	3.0	1.0	1.0										1		

XV. ASSESSMENT METHODOLOGY DIRECT:

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

XVI. ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Activities / Model		

XVII. SYLLABUS:

MODULE I	STRUCTURE OF CRYSTALLINE SOLIDS
	Structure of crystalline solids: Atomic structure & bonding in solids Unit cell, Space lattice, Crystal structures and its types-calculations of radius, Coordination Number and Atomic Packing Factor for different cubic structures, Indices for planes and directions Imperfection in solids, point defects, Line defects and Planar defects.

MODULE II	**PHASE DIAGRAMS**
	Phase diagrams: Basic terms Solid solutions Gibbs phase rule Lever rule cooling curves Phase diagrams construction of phase diagrams binary phase diagrams Al Si phase diagram Invariant reactions, eutectic, peritectic, eutectoid, peritectoid reactions, metatectic & monotectic reactions.
MODULE III	**ENGINEERING MATERIALS-I**
	Engineering Materials I: Steels and Iron Carbon phase diagram and heat treatment, study of iron carbon diagram. Construction of TTT diagrams, annealing, normalizing, hardening and tempering of steels.
MODULE IV	**ENGINEERING MATERIALS-II, III**
	Engineering Materials II: Cast Irons, Structure and properties of White cast iron, malleable cast iron, grey cast iron. Engineering Materials III: Non-ferrous metals and alloys, structure and properties of Aluminum Copper and its alloys, titanium and its alloys.
MODULE V	**ENGINEERING MATERIALS-IV**
	Engineering Materials IV: Ceramics, polymers and composites; crystalline ceramics, glasses, cermets, Structure, properties and applications; Classification, properties and applications of composites,classification, properties and applications of polymers.

TEXTBOOKS

1. Sidney H Avner, "Introduction to Physical Metallurgy", McGraw-Hill Education, 2nd Edition, 2008.

2. Donald R Askeland, Thomson, "Essentials of Material Science and Engineering", Thomson Press, 1st Edition, 2005.

REFERENCE BOOKS:

1. Kodgire, "Material Science and Metallurgy", Everst Publishing House, 12th Edition, 2002.

2. William, Callister, "Material science and Engineering", Wiley, 9th Edition, 2014.

VIII COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Introduction to outcome based education		
CONTENT DELIVERY (THEORY)			
2	Unit cell, Space lattice	CO 1	R1:2.6
3-4	Crystal structures and its types	CO 1	T1:2.6
5	Calculations of radius	CO 1, CO 2	T2:2.7 R1:2.18
6	Coordination Number and Atomic Packing Factor for different cubic structures	CO 1, CO 2	T2:2.22
7-9	Indices for planes and directions	CO 1, CO 2	T2:2.25
10	Imperfection in solids, point defects	CO 1, CO 2	T2:2.26 R1:2.55
11-13	Line defects and Planar defects	CO 1, CO 2	T2:2.16 R1:2.61
14	Phase diagrams: Basic terms-Solid solutions	CO 2, CO 3	T2:2.30 R1:2.58
18	Gibbs phase rule- Lever rule	CO 2, CO 3	T2:3.14 R1:4.31
20	Cooling curves Phase diagrams	CO 2	T2:3.14 R1:4.33
21-22	Construction of phase diagrams	CO 2	R1:4.36
23-24	Binary phase diagrams	CO 3	T2:3.18 R1:4.64
25-27	Al-Si phase diagram	CO 3	T2:3.22 R1:4.67
28	Invariant reactions, eutectic, peritectic	CO 3	T2:3.28 R1:4.67
29	Eutectoid, peritectoid reactions, metatectic& monotectic reactions	CO 3	T2:4.2 R1:4.67
30	Engineering Materials I: Steels and Iron	CO 3	T2:4.3 R1:4.71
31	Carbon phase diagram and heat treatment	CO 3, CO 4	T1:4.8 R2:4.68
32	Study of iron – carbon diagram, Construction of TTT diagrams	CO 3, CO 4	T2:4.15 R1:5.74
33	Annealing, normalizing, hardening and tempering of steels	CO 3, CO 4	T1:4.12 R2:5.75

34	Cast Irons, Structure and properties of White cast iron, malleable cast iron, grey cast iron	CO 3, CO 4	T1:4.8 R2:5.72
35	Cast Irons, Structure and properties of White cast iron, malleable cast iron, grey cast iron	CO 3, CO 4	T1:5.8 R1:5.73
36	Non-ferrous metals and alloys, structure and properties of Aluminum Copper and its alloys, titanium and its alloys	CO 4, CO 5	T1:5.14 R1:6.78
37	Non-ferrous metals and alloys, structure and properties of Aluminum Copper and its alloys, titanium and its alloys	CO 4, CO 5	T2:5.19 R1:6.81
38	Ceramics, polymers and composites	CO 4, CO 5	T1:6.4 R2:6.8
39	Crystalline ceramics, glasses, cermets	CO 4, CO 5	T2:7.7 R1:7.74
40	Structure, properties and applications	CO 4, CO 5	T1:7.12 R2:8.75
41	Classification, properties and applications of composites	CO 4, CO 5	T1:7.8 R1:8.72
42	Classification, properties and applications of composites	CO 4, CO 5	T1:8.8 R3:8.73
43	Classification, properties and applications of polymers.	CO 6	T1:9.14 R1:10.78
44	Classification, properties and applications of polymers.	CO 6	T2:9.19 R1:10.814
45	Classification, properties and applications of polymers.	CO 6	T1:10.4 R2:11.68
46	Calculations of radius in crystal structures	CO 6	T1:5.14 R1:6.78
47	Case study and critical analysis of cracks in Cast Iron and Austenitic Steel during casting	CO 5	T2:5.19 R1:6.81
48	An Overview on Types of White Cast Irons and High Chromium White Cast Irons	CO 5	T1:6.4 R2:6.8
49	Case study and critical analysis of cracks in malleable Cast Iron	CO 5,CO 6	T2:7.7 R1:7.74
50	Case study and critical analysis of cracks in Cast Iron and Austenitic Steel during casting	CO 5,CO 6	T1:7.12 R2:8.75
51	Case study and critical analysis of cracks in Cast Iron and Austenitic Steel during casting	CO 5,CO 6	T1:7.8 R1:8.72
52	Case study and critical analysis of cracks in Cast Iron and Austenitic Steel during casting	CO 5,CO 6	T1:8.8 R3:8.73
53	Case study and critical analysis of cracks in Cast Iron and Austenitic Steel during casting	CO 5,CO 6	T1:9.14 R1:10.78
54	Case study and critical analysis of cracks in Cast Iron and Austenitic Steel during casting	CO 5,CO 6	T2:9.19 R1:10.814

55	Case study and critical analysis of cracks in Cast Iron and Austenitic Steel during casting	CO 5,CO 6	T1:10.4 R2:11.68
PROBLEM SOLVING/ CASE STUDIES			
60	Describe about linear atomic density? Calculate the linear atomic density in [110] direction in the cooper crystal lattice in atoms per mm. copper is FCC and has a lattice constant of 0.351.	CO 1	T2:2.30 R1:2.58
61	Explain Hardenability and the method of testing using Jominy end quench.	CO 1	T2:2.26 R1:2.55
62	Classify stainless steels and mention their properties and applications.	CO 1	T2:2.22
63	Explain heat treatable aluminium alloys and give applications	CO 2	T2:3.14 R1:4.31
64	Justify " ti-6al-4v alloys are useful for aero space applications"	CO 2	T2:3.22
65	Draw the stages of structures from Solid to Liquid formation in binary system	CO 2	T2:3.14 R1:4.33
66	Describe about formation of intermediate phases in detail.	CO 3	T1:5.8 R1:5.73
67	Examine carbon percentage present in spheroidal cast iron?	CO 4	T1:5.14 R1:6.78
DISCUSSION OF DEFINITION AND TERMINOLOGY			
75	Module I	CO 1	T2:2.1
76	Module II	CO 2	T2:3.1
77	Module III	CO 3,4	T1:5.1
78	Module IV	CO 5	T1:7.1
79	Module V	CO 6	T1: 11.12
DISCUSSION OF QUESTION BANK			
80	Module I	CO 1	T2:2.1
81	Module II	CO 2	T2:3.1
82	Module III	CO 3,4	T1:5.1
83	Module IV	CO 5	T1:7.1
84	Module V	CO 6	T1: 11.12

Signature of Course Coordinator **HOD,ME**
Dr. Ch. Sandeep, Associate Professor

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

Department	**MECHANICAL ENGINEERING**				
Course Title	**DATA STRUCTURES**				
Course Code	ACSC08				
Program	B.Tech				
Semester	III				
Course Type	Core				
Regulation	UG.20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	3	1.5
Course Coordinator	Dr V Sitharamulu, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	ACSC01	I	Python Programming

II COURSE OVERVIEW:

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

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	whiteboard		Assignments	x	MOOC
✓	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
60%	Understand
20%	Apply
10%	Analyze

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

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

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

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

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

is given in table.

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

VI COURSE OBJECTIVES:

The students will try to learn:

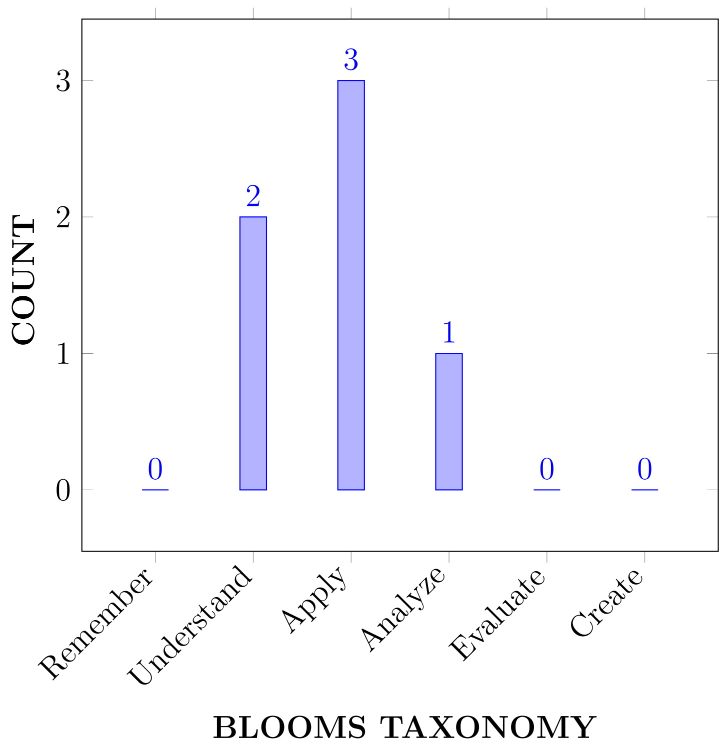
I	To provide students with skills needed to understand and analyze performance trade-offs of different algorithms / implementations and asymptotic analysis of their running time and memory usage.
II	To provide knowledge of basic abstract data types (ADT) and associated algorithms: stacks, queues, lists, tree, graphs, hashing and sorting, selection and searching.
III	The fundamentals of how to store, retrieve, and process data efficiently
IV	To provide practice by specifying and implementing these data structures and algorithms in Python.
V	Understand essential for future programming and software engineering courses.

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	3	CIA/ SEE/ Tech Talk/ Concept Videos
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	2	CIA/ SEE/ Tech Talk/ Concept Videos
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	2	CIA/ SEE/ Tech Talk/ Concept Videos

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO1	PO 1	**Understand** (knowledge) the concept of conventional digital communication system and (understand) various types of pulse analog modulation techniques for signals analysis by applying the principles of **mathematics, science,** and **engineering fundamentals**.	3
	PO 2	**Problem Analysis** on different types of algorithms to analyze space and time complexities.	4
	PO 3	**Design the Solutions** for finding space and time complexities of a complex algorithm and representing it by asymptotic notations	2
	PO 10	**Subject matter and speaking style** assessed in explanation of various algorithms, algorithm complexity.	2
	PSO1	**Design and analyze** complex algorithms and specify its space and time complexities and representing it by asymptotic notations for faster processing of data.	3
	PSO3	**Make use of modern** computer tools for finding space and time complexities of a complex algorithm	1
CO 2	PO 1	**Make use** of broad knowledge of searching and sorting techniques for an efficient search from a data structure and optimize the efficiency of other algorithms by applying the knowledge of mathematics, science, Engineering fundamentals.	1
	PO 2	**Problem Analysis** on different types of search sort algorithms to analyze space and time complexities.	5

	PO 3	**Design/Development of Solutions** using appropriate searching and sorting techniques for designing a solution for complex Engineering problems.	2
	PO 5	**Implementation of** different sorting and searching techniques for given problem with the help of computer software	1
	PO 10	**Subject matter and speaking style** assessed in explanation of searching and sorting along with efficiency of searching and sorting techniques in terms of space and time complexity	2
	PO 12	**Keeping current in CSE and advanced engineering concepts** of various searching , sorting and respective time and space complexity by tech talk, concept videos and open ended experiments.	3
	PSO1	**Understand** complex problems and analyzing it and apply appropriate sorting and searching techniques for data processing.	4
	PSO2	**Applying** various selecting and sorting techniques while designing and developing information retrieval systems and its applications	2
	PSO3	**Make use of** various selecting and sorting techniques and extend the knowledge for advance frame works and platforms which are necessary for engineering practices and higher studies or become an entrepreneur.	1
CO 3	PO 1	**Make use of** linear and nonlinear data structures to organize the data in a particular way so to use them in the most effective way by applying the basic knowledge of mathematics, science, engineering fundamentals	2
	PO 2	**Problem analysis:** Organizing the given data in particular way by performing the operations on linear and nonlinear data structures to use the data in the most effective way.	7
	PO 3	**Recognize the** need of linear and nonlinear data structures such as linked list, array, stack and queue by Designing solutions for complex Engineering.	5
	PO 4	**Conduct Investigations** Conduct Investigations of Complex Problems: Ability to apply operations on linear and nonlinear data structures in order to organize the given data in a particular way	4
	PO 5	**Implementation of** Implementation of different operations on linear and nonlinear data structures for given problem with the help of computer software	1
	PO 10	**Subject matter and speaking style** assessed in explanation of linear and nonlinear data structures like linked lists, stacks and queues	2

	PO 12	**Keeping current in** CSE and advanced engineering concepts of linear and nonlinear data structures like linked lists, stacks and queues by tech talk, concept videos and open-ended experiments	3
	PSO1	**Understand** complex problems and analyzing it and apply appropriate operations on linear or nonlinear data structures for Developing the solution.	5
	PSO2	**Applying** various linear or nonlinear data structures while designing and developing information retrieval systems and its applications	2
	PSO3	**Make use of** various linear or nonlinear data structures and extend the knowledge for advance frame works and platforms which are necessary for engineering practices and higher studies or become an entrepreneur.	1
CO 4	PO 1	**Make use of** linear and nonlinear data structures for solving real time applications by applying the basic knowledge of mathematics, science, engineering fundamentals	3
	PO 2	**Problem analysis:**Solving real time applications by performing the operations on linear or nonlinear data structures.	7
	PO 3	**Recognize the** need of linear and nonlinear data structures such as linked list, array, stack and queue for Designing real time applications.	2
	PO 4	**Conduct Investigations of Complex Problems:** Ability to apply operations on linear or nonlinear data structures in order to solve real time applications.	4
	PO 5	**Implementation of** different operations on linear and nonlinear data structures for solving real time applications with the help of computer software	1
	PO 10	**Subject matter and speaking style** assessed in explanation of linear and nonlinear data structures like linked lists, stacks, queues, trees and graphs	2
	PO 12	**Keeping current** in CSE and advanced engineering concepts of linear and nonlinear data structures like linked lists, stacks, queues, trees and graphs by tech talk, concept videos and open-ended experiments for solving real time applications.	3
	PSO1	**Understand** complex problems and analyzing it and apply appropriate operations on linear or nonlinear data structures for solving real time applications.	5
	PSO2	**Applying** various linear or nonlinear data structures while designing and developing information retrieval systems and its applications	1

	PSO3	**Make use of** various linear or nonlinear data structures and extend the knowledge for advance frame works and platforms which are necessary for engineering practices and higher studies or become an entrepreneur.	1
CO 5	PO 1	**Understand** the knowledge of hashing techniques and collision resolution methods and implementing for specified problem domain using knowledge of mathematics, science and engineering fundamentals	1
	PO 3	**Design the Solution** for efficiently accessing data with respect to performance by using hashing techniques and collision resolution methods	2
	PO 5	**Implementation of** hashing techniques and collision resolution methods for efficiently accessing data with respect to performance with the help of computer software	1
	PO 10	**Subject matter and speaking style** assessed in explanation of Hashing, Collision techniques	2
	PSO1	**Understand** complex problems and analyzing it and apply appropriate hashing techniques and collision resolution methods for efficiently accessing data with respect to performance.	4
	PSO2	**Applying** various hashing techniques and collision resolution methods while designing and developing information retrieval systems and its applications	1
	PSO3	**Build** sufficient knowledge hashing techniques and collision resolution methods so that new product can be developed, which leads to become successful entrepreneur in the present market.	1
CO 6	PO 1	**Understand** various types of data structures in terms of implementations and choose appropriate data structure for specified problem domain using knowledge of mathematics, science and engineering fundamentals	3
	PO 2	**Problem Analysis:** Recognize the importance of suitable data structures in checking the efficiency of algorithms used for complex engineering problems.	7
	PO 3	**Design the Solution** complex problems or efficiently accessing data with respect to performance by using hashing techniques and collision resolution methods	5
	PO 4	**Conduct Investigations of Complex Problems:** Ability to apply operations on linear or nonlinear data structures in order to solve real time applications.	4
	PO 5	**Understand** the Implementation of various types of data structures with the help of computer software	1
	PO 10	**Subject matter and speaking** style assessed in explanation of Implementation of various types of data structures.	2

	PO 12	**Keeping current in CSE** and advanced engineering concepts of Implementation of various types of data structures by tech talk, concept videos and open ended experiments	3
	PSO 1	**Understand** complex problems and analyzing it and apply Implementation of various types of data structures.	5
	PSO 2	**Applying** Implementation of various types of data structures while designing and developing information retrieval systems and its applications	1
	PSO 3	**Build** sufficient knowledge Implementation of various types of data structures so that new product can be developed, which leads to become successful entrepreneur in the present market.	1

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

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

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

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

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

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

XVI ASSESSMENT METHODOLOGY DIRECT:

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

XVII ASSESSMENT METHODOLOGY INDIRECT:

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

XVIII SYLLABUS:

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

TEXTBOOKS

1. Rance D. Necaise, —Data Structures and Algorithms using Python, Wiley Student Edition.

2. Benjamin Baka, David Julian, —Python Data Structures and Algorithms, Packt Publishers, 2017.

REFERENCE BOOKS:

1. S. Lipschutz, —Data Structures , Tata McGraw Hill Education, 1st Edition, 2008.
2. D. Samanta, —Classic Data Structures, PHI Learning, 2nd Edition, 2004.

WEB REFERENCES:

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

COURSE WEB PAGE:

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

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	https://www.iare.ac.in/?q=courses/computer-science-and-engineering-autonomous/datastructures
CONTENT DELIVERY (THEORY)			
1	Basic concepts: Introduction to Data Structures	CO 3	T1:1.1.3 R2 : 1.2
2	Classification of data structures	CO 3	T1:1.1.3 R2 : 1.4
3	Operations on data Structures	CO 3	T1:1.2
4	Recursive algorithm, Performance Analysis	CO 1	T1:1.2 T1:5.1
5	Searching techniques: Linear search and binary search	CO 2, CO 6	T1:5.1
6	Searching techniques: Fibonacci search and comparison	CO 2, CO 6	T1:5.1
8	Sorting techniques: Bubble sort, selection sort and companding	CO 2 CO 6	R1:14.5

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

CONTENT DELIVERY (THEORY)			
38	Binary tree :Binary Tree properties	CO 3, CO 4	T1:13.1
39	Binary tree representation using array	CO 3, CO 4	T1:13.2
40	Binary tree representation using linked list	CO 3, CO 4	T1:13.2
41	Binary tree traversal, binary tree variants	CO 3, CO 4	T1:13.2
42	Application of trees	CO 4	T1:13.2.3
44	Graphs: Basic concept, graph terminology	CO 3	R2 : 8.2
45	Types of graphs, Representation of graph	CO 3	R2 : 8.2
46	Graph traversals :DFS and BFS, Application of graphs	CO 3	T2:6.2
48	Minimum Spanning Trees-Prims and Kruskal algorithms	CO 4	T1:6.1 T2:5.6
50	Binary search trees, properties	CO 3	T1:13.2.3
51	Binary search trees operations	CO 3	T1:13.2.3
52	AVL trees	CO 3	T1:14.3
53	M- Way search trees, B trees	CO 3	T1:14.3
54	Hashing, Collision	CO 5	R2 : 6.4
7	Problems on linear search, binary search and Fibonacci search.	CO 2	T1:5.1
11	Problems on bubble sort, selection and insertion sort	CO 3, CO 4	T1:5.2 R2 : 10.2
12	Problems on quick and merge sort	CO 3, CO 4	T1:5.2 R2 : 10.2
15	Problems on Arithmetic expression conversion and evaluation	CO 3, CO 4	T1:7.2
27	Problems on single linked list to add, delete element	CO 3, CO 4	T1:9.8
28	Problems on double linked list to add, delete element	CO 3, CO 4	T1:9.8
33	Problems on circular linked list to add, delete element	CO 3, CO 4	T1:9.4
34	Problems on double linked list to add, delete element	CO 3, CO 4	T1:9.3
35	Problems on stack using linked list	CO 3, CO 4	T1:9.7
36	Problems on queue using linked list	CO 3, CO 4	T1:9.8
43	Problems on Binary tree :creation ,insertion and deletion of a node	CO 3, CO 4	T1:13.2
47	Problems on Graph Traversal: DFS and BFS	CO 3, CO 4	T2:6.2

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

Course Coordinator **HOD,ME**
Dr V Sitharamulu, Associate Professor

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

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**MACHINE DRAWING THROUGH CAD LABORATORY**				
Course Code	AMEC08				
Program	B.Tech				
Semester	Three				
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Dr.G.V.R. Seshagiri Rao, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
Foundation	AMEC03	II	Computer Aided Engineering Drawing

II COURSE OVERVIEW:

Machine drawing is used to communicate the necessary technical information required for manufacture and assembly of machine components. Students practice the development of drawings of machine components as per Bureau of Indian Standards (BIS) and assembly using industry leading mechanical design softwares. This course is central to developing students ability to easily develop a full range of products, from single parts to assemblies containing thousands of components with accurate fit and therefore involves economic, societal, safety and manufacturing aspects.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Machine Drawing Through CAD 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 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 labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

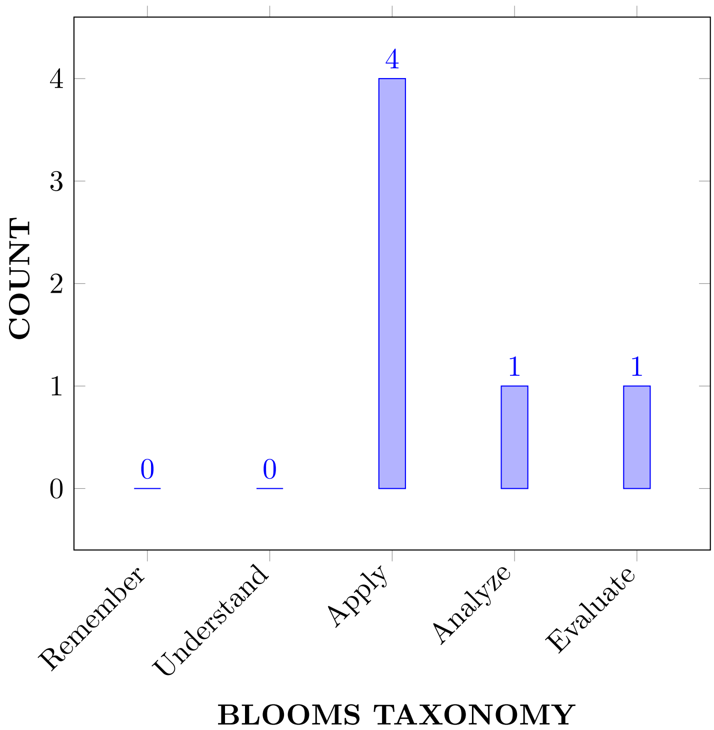
I	The Code of drawing practice as per BIS conventions for mechanical elements using AutoCAD.
II	The 2D drawing of joints, couplings, bearings and keys and their sectional views.
III	The preparation of component drawings, assembly drawings and bill of materials for selected assemblies.
IV	The part drawings of the assembly of various machines and engine components.

VII COURSE OUTCOMES:

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

CO 1	**Select** the conventional representation of materials and machine elements for assembly drawing work.	Apply
CO 2	**Classify** the different types of sectional views to expose internal surfaces of machine elements.	Analyze
CO 3	**Explain** the importance of the linking functional and visualization aspects in the preparation of the part drawings for the design process.	Evaluate
CO 4	**Illustrate** various machine components through drawings for Assembly	Apply
CO 5	**Identify** the different types of couplings are used for fastening components that require frequent assembly and disassembly.	Apply
CO 6	**Develop** detailed assembly drawings of Engine parts, Tailstock, Machine vice and safety valves to facilitate its manufacture.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	Lab Exercises/CIA/SEE
PO 3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	3	Lab Exercises/CIA/SEE
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	Lab Exercises/CIA/SEE
PO 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	3	Lab Exercises/CIA/SEE
PO 9	**Individual and Team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	Lab Exercises/CIA/SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Lab Exercises/CIA/SEE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 2	**Identify** the various mechanical machine elements to **illustration** of their materials and shape in an assembly drawings .	2
	PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product **development**using CAD/CAM softwares.	1
CO 2	PO 2	**Identify** the various mechanical machine elements to **illustration** of their materials and shape in an assembly drawings .	2
	PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product **development**using CAD/CAM softwares.	1
CO 3	PO 3	**Design solutions**for complex engineering problems and design system components for the public **health and safety,**and the cultural, societal, and **Environmental** considerations.	3
	PO 5	**Apply appropriate techniques, resources,** and **modern engineering tool** for modeling of various machine components to **complex engineering** activities with an understanding of the limitations.	2
CO 4	PO 3	**Design solutions**for complex engineering problems and design system components for the public **health and safety,**and the cultural, societal, and **Environmental** considerations.	3
	PO 4	Use research-based knowledge and research methods including **Design**of mechanical components,**analysis** and **interpretation**of data, and **synthesis** of the information to provide valid conclusions.	4
CO 5	PO 9	Function **effectively**as an individual, and as a member or leader in diverse teams, and in **multidisciplinary** to settings.	2
	PO 10	**Write**effective reports and **design** documentation, make effective presentations, and give and receive clear instructions on **complex engineering** activities.	3
	PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product **development**using CAD/CAM softwares.	1
CO 6	PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product **development**using CAD/CAM softwares.	1
	PO 9	Function **effectively**as an individual, and as a member or leader in diverse teams, and in **multidisciplinary** to settings.	2

	PO 10	**Write**effective reports and **design** documentation, make effective presentations, and give and receive clear instructions on **complex engineering** activities.	3

XI COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 2, PO 3, PO 5	SEE Exams	PO 2, PO 3, PO 5	Seminars	-
Laboratory Practices	PO2, PO3, PO4, PO 5, PO 9, PO 10	Student Viva	PO2, PO3, PO5	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**CONVENTIONAL REPRESENTATION**
	Conventional representation of materials, common machine elements and parts such as screws, nuts, bolts, keys, gears, webs and ribs; Introduction to AutoCAD.
WEEK II	**SECTIONAL VIEWS**
	Types of sections, selection of section planes and drawing of sections and auxiliary sectional views, parts not usually sectioned.

WEEK III	**DIMENSIONING**
	Methods of dimensioning, general rules for sizes, and placement of dimensions for holes, centers, and curved and tapered features.
WEEK IV	**MACHINE ELEMENTS**
	Drawing of machine elements and simple parts; Selection of orthogonal views and additional views for the following machine elements and parts with drawing proportion, popular forms of screw threads, bolts, nuts and stud bolts.
WEEK V	**KEYS AND COTTER JOINTS**
	Keys, cotter joints, and knuckle joint.
WEEK VI	**RIVETED JOINTS**
	Riveted joints for plates.
WEEK VII	**COUPLINGS**
	Shaft couplings and spigot joint.
WEEK VIII	**BEARINGS**
	Journal, pivot, and collar bearing.
WEEK IX	**ASSEMBLY DRAWINGS-I**
	Assembly drawings for the Engine parts–stuffing box, Eccentrics, I.C. engine connecting rod.
WEEK X	**ASSEMBLY DRAWINGS-II**
	Assembly drawings for the Screw jack.
WEEK XI	**ASSEMBLY DRAWINGS-III**
	Assembly drawings for the Machine vice and tailstock.
WEEK XII	**ASSEMBLY DRAWINGS-IV**
	Assembly drawings for the Rams-bottom Safety Valve

TEXTBOOKS

1. K.L. Narayana, P. Kannaiah, K. Venkata Reddy, "Machine Drawing", New Age Publishers, 3rd Edition, 2012.
2. K.C. John, "Text book of Machine Drawing", PHI Eastern Economy, 1st Edition, 2010.
3. P.S Gill, "Machine Drawing", S.K Kataria and Sons, 1st Edition, 2013.

REFERENCE BOOKS:

1. N. D. Bhatt, V. M Pancahal, "Machine Drawing", Charotar, 1st Edition, 2014.
2. R. K. Dhavan, "A Text book of Machine drawing", S.Chand Publication and Co, New Delhi, 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	Conventional representation of materials, common machine elements and parts such as screws, nuts, bolts, keys, gears, webs and ribs; Introduction to AutoCAD.	CO1	T1:1.8-2.5
2	Types of sections, selection of section planes and drawing of sections and auxiliary sectional views, parts not usually sectioned.	CO 1, CO 2	T1:4.1-5.6
3	Methods of dimensioning, general rules for sizes, and placement of dimensions for holes, centers, and curved and tapered features	CO 1, CO 2	T1:1.1-2.1
4	Drawing of machine elements and simple parts; Selection of orthogonal views and additional views for the following machine elements and parts with drawing proportion, popular forms of screw threads, bolts, nuts and stud bolts.	CO1, CO 2	T1:5.1-7.4
5	Keys, cotter joints, and knuckle joint.	CO 3	T1:7.5
6	Riveted joints for plates.	CO 3	T1:8.1-8.6
7	Shaft couplings and spigot joint.	CO 4	T1:9.1-9.10
8	Journal, pivot, and collar bearing.	CO 4	T1:12.1-12.5
9	Assembly drawings for the Engine parts–stuffing box, Eccentrics, I.C. engine connecting rod.	CO 5	R1:13.2
10	Assembly drawings for the Screw jack	CO 6	T1:15.5
11	Assembly drawings for the Machine vice and tailstock	CO 6	T1:15.6-15.8
12	Assembly drawings for the Rams-bottom Safety Valve	CO 6	T1:15.9

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1. 1	Explore the application of AutoCAD software and Design of various machine elements as Per BIS.
2. 2	Instead of 2D drawings develop the components or assembly of components in 3D using AutoCAD software.
3. 3	Prepare the real time machine components in reverse engineering.
4. 4	To illustrate new designs by using pictorial drawings for understanding exploded assemblies.

Signature of Course Coordinator **HOD, ME**
Dr.Gvr Seshagiri Rao, Associate Professor

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

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**MATERIALS AND SOLID MECHANICS LABORATORY**				
Course Code	AMEC09				
Program	B.Tech				
Semester	III	ME			
Course Type	CORE				
Regulation	IARE - UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Dr. K.Viswanath Allamraju, Associate Professor				

I COURSE OVERVIEW:

Materials and mechanics of solids laboratory is designed to examine samples to detect surface and internal flaws, determine micro structural features, evaluate heat treatments and ensure conformance to required specifications. Root cause failure analysis can also be performed when performance issues occur with metal products. One of the principle concerns of an engineer is the analysis of materials used in structural applications. The term structure refers to any design that utilizes materials that support loads and keeps deformation within acceptable limits. Designing machines, structures, and vehicles, which are reliable as well as safe and cost effective, requires a proper knowledge of engineering as well as material selection.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB03	III	Engineering Mechanics

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Materials and Solid Mechanics 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 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 labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	The processes of cold/hot working, re-crystallization, grain growth and micro structural properties of materials.
II	The parameters such as factor of safety, Poisson's ratio, three elastic moduli and their relationships in the selection and characterization of a material.
III	The theory of pure torsion, bending, stiffness, slope and deflection of beams.

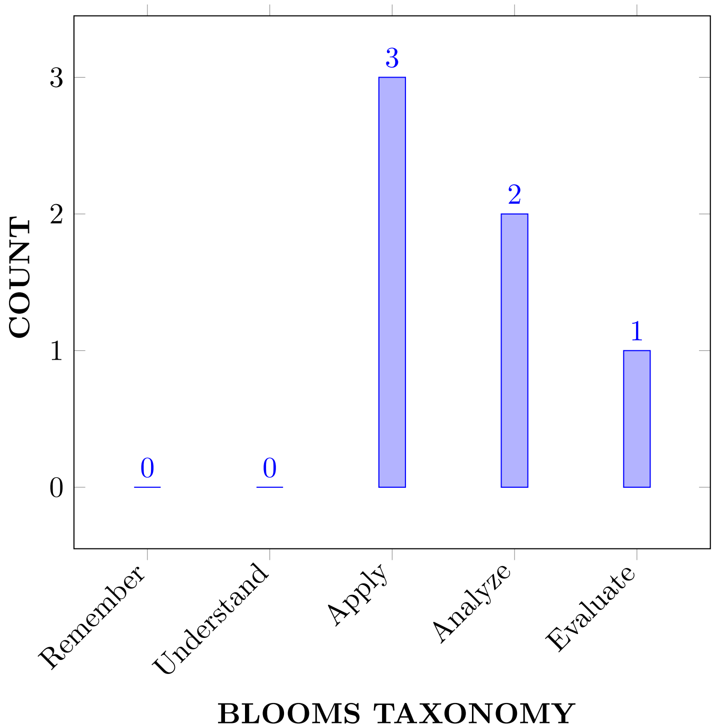
VII COURSE OUTCOMES:

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

CO 1	**Utilize** the concepts crystallography, crystal structures, crystallographic planes, and miller indices to analyse the microstructural properties of materials.	Apply

CO 2	**Make use of** the Jominy end quench test apparatus to measure the capacity of steel hardenability in depth under a given set of conditions.	Apply
CO 3	**Distinguish** the regions of elasticity and plasticity, stress-strain relationships under various types of loads by conducting a tensile test on universal testing machine.	Apply
CO 4	**Analyze** the mechanical properties of a material by conducting compression and torsion tests on different materials.	Analyze
CO 5	**Compare** the hardeness values of ferrous and non ferrous materials by conducting experiments on Rockwell and Brinell's hardness testing machines.	Analyze
CO 6	**Determine** the impact strength of a material by adopting Charpy and Izod test procedures.	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

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

PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Lab Exercises/CIA/SEE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	**Apply the knowledge of Sciences and Engineering principles** to **identify** the properties and micro structural behaviour of different materials to know their specifications.	3
	PO 2	**Identify and analyse the principles** to **utilize** appropriate materials in design considering engineering properties and micro structural characteristics, sustainability, cost and weight.	4
CO 2	PO 1	**Apply** the knowledge of **science and engineering principles** to **analyze** mechanical properties of materials, specifically capacity of a steel hardenability over a depth for different condintions.	3
	PO 2	**Identify, formulate and analyse** the stresses, strains at a point with their relationships for a given material and variation of hardenability of a material.	3
CO 3	PO 1	**Apply the knowledge of science and engineering principles** to **distinguish** the regions of elasticity, plasticity and phenomena of strain hardening of different materials by conducting a test on suitable machine.	2
	PO 4	**Analyze** and **interpret** the data obtained in a graphical form by conducting a tensile test on universal testing machine on a selected material.	2
CO 4	PO 1	**Apply** the knowledge of **science and engineering principles** to **analyze** the mechanical properties of materials by conducting compression and torsion tests on suitable machines.	2
	PSO 1	**Identify** and **evaluate** compression and torsion properties of different materials and **calculate** the modulus of rigidity of a material.	3

CO 5	PO 2	**Identify** the engineering materials, **determine and compare** the hardnes values with both Rockwell and Brinell test procedres.	3
	PO 4	**Analyze** and **interpret** the values of hardness for different ferrous and non ferrous materials using different scales on Rockwell hardness machine.	2
CO 6	PO 2	**Identify and analyse** the impact strengths for different materials by adopting Charpy and Izod test procedures and **determine** the toughness of materials.	3

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

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

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**MICROSTRUCTURE OF PURE METALS**
	Preparation and study of the micro Structure of pure metals like iron, cu and al.
WEEK II	**MICROSTRUCTURE OF STEELS**
	Preparation and study of the microstructure of mild steels, low carbon steels, high–C steels.
WEEK III	**MICROSTRUCTURE OF CAST IRON**
	Study of the micro structures of cast irons.
WEEK IV	**MICROSTRUCTURE OF COPPER**
	Study of the micro structures of copper.
WEEK V	**MICROSTRUCTURE OF HIGH CARBON STEEL**

	Study of the micro structures of high carbon steel
WEEK VI	**TENSION TEST**
	To Find percentage of elongation and youngs modulus of a material.
WEEK VII	**TORSION TEST**
	To find the torsional rigidity of a material.
WEEK VIII	**Brinell HARDNESS TEST**
	To find the Hardness number of given material.
WEEK IX	**Rockwell HARDNESS TEST**
	To find the Hardness number of given material.
WEEK X	**SPRING TEST**
	Testing on compressive and elongation springs.
WEEK XI	**COMPRESSION TEST**
	Compression test on concrete cube.
WEEK XII	**Charpy IMPACT TEST**
	To find the Imapct strength of a given specimen
WEEK XIII	**IZOD IMAPCT TEST**
	To find the Imapct strength of a given specimen
WEEK XIV	**SHEAR TEST**
	Punch shear test on aluminium sheet.

TEXTBOOKS

1. H Modi, Seth, Hydraulics, Fluid Mechanics and Hydraulic Machinery, Rajsons, Publications, 21st Edition, 2017.

2. Pulkrabek, Engineering Fundamentals of IC Engines, Pearson Education, 2nd Edition, 2008.

REFERENCE BOOKS:

1. Dr. R K Bansal, A Text Book of Fluid Mechanics and Hydraulic Machines, Laxmi Publications, 9th Edition, 2015.

2. Mathur, Sharma, IC Engines, DhanpatRai and Sons, 3rd 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	Preparation and study of the micro Structure of pure metals like iron, cu and al..	CO 1, CO 2	T1:7.10
2	Preparation and study of the microstructure of mild steels, low carbon steels, high–C steels.	CO 1, CO 2	T1:11.5
3	Study of the micro structures of cast irons.	CO 3	T1:7.7
4	Study of the micro structures of copper.	CO 4, CO 5	T1:21.12
5	Study of the micro structures of high carbon steel	CO 5, CO 6	T1:21.5

6	To Find the percentage of elongation and youngs modulus of a material.	CO 4, CO 6	T1:23.2
7	Find the torsional rigidity of a material.	CO 4, CO 6	T1:24.3
8	Find the Hardness number of given material.	CO 6	R2:2.6
9	Find the Hardness number of given material.	CO 5, CO 6	T2:3.18
10	Testing on compressive and elongation springs.	CO 5, CO 6	T2:3.18
11	Compression test on concrete cube.	CO 5, CO 6	R2:7.12
12	Find the Imapct strength of a given specimen.	CO 6	T2:3.18
13	Find the Imapct strength of a given specimen.	CO 5, CO 6	R2:9.12
14	Punch shear test on aluminium sheet.	CO 6	T2:8.18

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**NDT:** Determination of internal defects using non destructive testing.
2	**Deflection:** Determine the slope and deflection for cantilever and simply supported beams.
3	**Shear Test:** Determine the shear stress for a riveted joint
4	**Deformation:** Determine the deformation of a tapering composite bar by applying the principle of superposition

Signature of Course Coordinator **HOD, ME**
Dr. K.Viswanath Allamraju, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)

Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**DATA STRUCTURES LABORATORY**				
Course Code	ACSC10				
Program	B.Tech				
Semester	III	ME			
Course Type	Core				
Regulation	IARE - UG 20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Ms. K Laxminarayanamma, Assistant Professor				

I COURSE OVERVIEW:

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

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	ACSC02	I	Python Programming Laboratory
B.Tech	ACSC08	III	Data Structures

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	To provide students with skills needed to understand and analyze performance trade-offs of different algorithms / implementations and asymptotic analysis of their running time and memory usage.

II	To provide knowledge of basic abstract data types (ADT) and associated algorithms: stacks, queues, lists, tree, graphs, hashing and sorting, selection and searching. .
III	The fundamentals of how to store, retrieve, and process data efficiently.
IV	To provide practice by specifying and implementing these data structures and algorithms in Python.
V	Understand essential for future programming and software engineering courses.

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL

VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises
PO 2	**Problem Analysis:** Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences	3	Lab Exercises
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	Lab Exercises
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions	2	Lab Exercises
PO 5	**Modern Tool Usage:**Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1	Lab Exercises
PO 6	**The Engineer and Society** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice	2	Lab Exercises
PO 8	**Ethics** Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice	3	Lab Exercises
PO 9	**Individual and Teamwork** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	3	Lab Exercises
PO 10	**Communication:** Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	4	Lab Exercises

PO 12	**Life - Long Learning:**Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	2	Lab Exercises
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	2	Lab Exercises
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	**Justification for mapping (Students will be able to)**	No. of Key Competencies
CO 1	PO 1	Identify appropriate searching technique for efficient retrieval of data stored location by applying the **principles of Mathematics and Engineering** , **Scientific principles and methodology**,**engineering disciplines to integrate / support study**	3
	PO 2	Identify appropriate searching technique for efficient retrieval of data stored location by applying Problem Analysis **Problem statement and system definition**,**Information and data collection**,**Solution development or experimentation / Implementation**	3
	PO 3	**Identify** appropriate searching technique for efficient retrieval of data stored location by applying **Design/Development of Solutions**	3
	PO 4	Identify**apply**appropriate searching technique for efficient retrieval of data stored location by applying **Conduct Investigations of Complex Problems**	2
	PO 5	Identify**apply**appropriate searching technique for efficient retrieval of data stored location by applying Computer software / simulation packages / diagnostic equipment / technical library resources / literature search toolsl	1

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

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

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

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

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

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

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

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

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

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

WEEK XII	**IMPLEMENTATION OF BINARY SEARCH TREE**
	Write a Python program that uses functions to perform the following: a. Create a binary search tree. b.Traverse the above binary search tree recursively in pre-order, post-order and in-order. c. Count the number of nodes in the binary search tree.

TEXTBOOKS

1. Rance D. Necaise, "Data Structures and Algorithms using Python", Wiley Student Edition.
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2. Yashavant Kanetkar, Aditya Kanetkar, —Let us Python‖, BPB publication, 1st Edition, 2019.
3. Ashok Kamthane, Amit Kamthane, —Programming and Problem Solving with Python‖, McGraw Hill Education (India) Private Limited, 2018.
4. Taneja Sheetal, Kumar Naveen, —Python Programming – A modular approach‖, Pearson, 2017.
5. R Nageswara Rao, —Core Python Programming‖, Dreamtech Press, 2017 Edition.

WEB REFERENCES:

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2. https://python.swaroopch.com/oop.html
3. https://python-textbok.readthedocs.io/en/1.0/Object-Oriented-Programming.html
4. https://www.programiz.com/python-programming/
5. . https://www.geeksforgeeks.org/python-programming-language

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Searching Techniques	CO 1	T1
2	Sorting Techniques.	CO 2	T1
3	Sorting Techniques	CO 2	T1,T2
4	Implementation of Stack and Queue	CO 3	T1,T2
5	Applications of Stack.	CO 3	T1, W1
6	Implementation of Single Linked List	CO 4	T1,W2
7	Implementation of Circular Single Linked List.	CO 4	T1,W3

8	Implementation of Double Linked List	CO 4	T2,W3
9	Implementation of Stack Using Linked List.	CO 3,CO 4	T2,W2
10	Implementation of Queue Using Linked List	CO 3,CO 4	T2,W5
11	Graph Traversal Techniques.	CO 6	T2,W2
12	Implementation of Binary Search Tree	CO 5	T1,W5

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Twin vortex formation:** Design a Data Structure SpecialStack that supports all the stack operations like push(), pop(), isEmpty(), isFull() and an additional operation getMin() which should return minimum element from the SpecialStack. All these operations of SpecialStack must be O(1). To implement SpecialStack, you should only use standard Stack data structure and no other data structure like arrays, list, . etc.
2	**Open channel:** In class, we studied binary search trees that do not allow us to insert duplicate elements. However, sometimes we do need to store duplicates. For example, a database of student marks might contain one record for every mark by every student; so if you've taken two courses, there will be two records with the same key (your student number) and different data (your two marks). To accomplish this, we might use a data structure called a "BST with duplicates", or BSTD
3	**Capillary action:** The variable tos in the Stack class is the index of the array element that would be filled the next time push() is called. Modify the code so that tos is the index of the top element actually in use. In other words, tos is to be the index of the top array element occupied by a value that has been "pushed" onto the stack. Write your changes on the code above. Don't forget to fix the comments. You do not need to add preconditions as in part-a.
4	**Buoyancy** Given an adjacency matrix representation of a graph, describe with pseudo code an algorithm that finds a single path, if one exists, between any two different vertices.
5	**Flow through pipes:** There is a garage where the access road can accommodate any number of trucks at one time. The garage is building such a way that only the last truck entered can be moved out. Each of the trucks is identified by a positive integer (a truck-id). Write a program to handle truck moves, allowing for the following commands: a) On-road (truck-id); b) Enter-garage (truck- id); c) Exit-garage (truck-id); d) Show-trucks (garage or road); If an attempt is made to get out a truck which is not the closest to the garage entry, the error message Truck x not near garage door

Signature of Course Coordinator **HOD,ME**
Mrs. K LAXMINARAYANAMMA, Assistant Professor

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

COURSE DESCRIPTION

Department	**Mechanical Engineering**				
Course Title	**Kinematics of Machines**				
Course Code	AMEC10				
Program	B.Tech				
Semester	IV				
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr K. Viswanath Allamraju, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB002	II	Engineering Mechanics
B.Tech	AMEB001	II	Engineering Drawing

II COURSE OVERVIEW:

Mechanical devices are designed to have mobility to perform certain functions. The theory behind the study of Kinematics of Machine leads us to design machines by understanding the relationship between the geometry and the motion of various parts of machine. This course will provide the knowledge on how to analyze the motions of mechanisms and design synthesis mechanisms to give required mobility. This includes relative motion analysis and design of gears, gear trains, cams, linkages and steering mechanism gears by adopting simultaneously both graphical and analytical approaches to estimate displacement, velocity and acceleration of links in a machine.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Kinematics of Machines	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
25 %	Understand
50 %	Apply
25 %	Analyze
0 %	Evaluate
0 %	Create

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

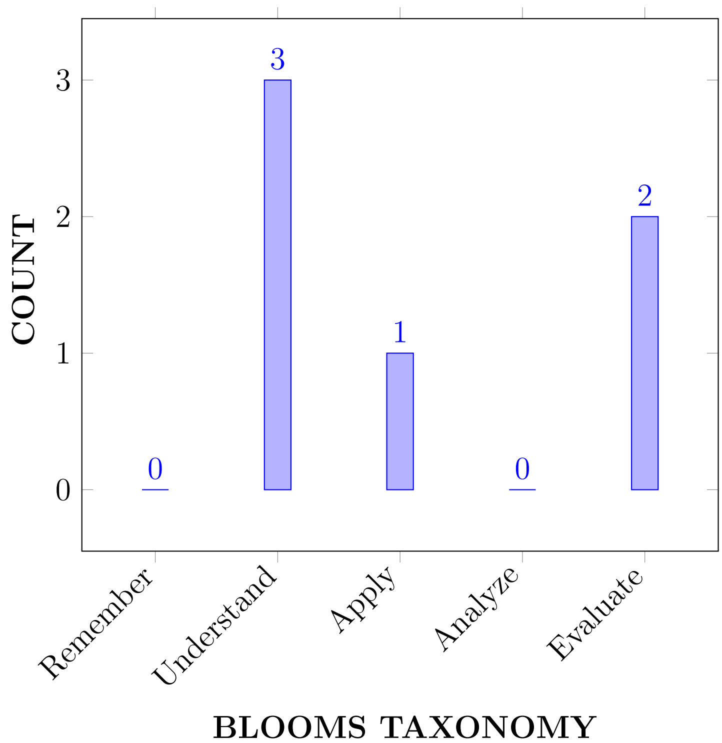
I	The basic concepts of Machine design to develop Mechanisms and Machines by using type synthesis , number synthesis and dimensional synthesis.
II	The Kinematics from the geometric point of view to determine mobility ,velocity and acceleration using graphical methods.
III	The Mechanisms with lower pairs to obtain steering, copying and straight line motions in automobiles and other allied applications.
IV	The Kinematic analysis and synthesis of cams imparting motion to knife edged, roller and mushroom followers , Gears and Gear trains..

VII COURSE OUTCOMES:

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

CO 1	**Discuss** thetypes of the kinematic synthesis for building a mechanism/Machine for mobility.	Understand
CO 2	**Illustrate** the velocity and acceleration analysis of various mechanisms by relative velocity method and I Center method.	Understand
CO 3	**Identify** the various mechanisms for the approximate straight line motions.	Apply
CO 4	**Justify** the importance of steering gear mechanisms for optimum operation of automobile vehicles.	Evaluate
CO 5	**Develop** the Cam profiles for different motions of various followers .	Evaluate
CO 6	**Illustrate** the design function of planetary gear train system and its methods of evaluationfor gear train value.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/Quiz/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	CIE/Quiz/AAT
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	CIE/Quiz/AAT
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	2	CIE/Quiz/AAT
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	2	CIE/Quiz/AAT
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	CIE/Quiz/AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2	CIE/Quiz/AAT
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	3	Quiz
PSO 3	Focus on ideation and research towards product development using additive manufacturing, CNC simulation and high speed machining.	2	Quiz

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** to classify various kinematic systems	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	**Identify the problem statement dentify the problem statement, formulation , data collection ,validation and interpretation** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	5
	PO 10	**Identify the problem statement** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	2
CO 2	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** and determine the velocity of various mechanisms at different conditions	3
	PO 2	Illustrate the performance parameters of four bar mechanisms **first principles of Mathematics and engineering sciences and identify the problem statement, formulation , data collection, validation and interpretation.**	5
	PO 5	**Identify the problem statement** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	1
CO 3	PO 1	Identify the velocity and acceleration values of mechanisms **using principles of mathematics, science, and engineering fundamentals.**	3
	PO 7	**Identify the problem statement, socio economic and environmental** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	2
CO 4	PO 1	Justify the knowledge of different forces (**scientific Principles and mathematical principles**) for steering gear mechanisms and describe different performance parameters.	3
	PO 2	Determine the condition for correct steering **and also identify the problem statement, formulation , data collection ,validation and interpretation** of various steering mechanisms	5
2-4	PO 3	**Identify the customer needs, investigate, innovate** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	5
CO 5	PO 1	Develop the fundamentals of engineering and science in identifying the cam profile **using the fundamentals of engineering and mathematical equations**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 8	**Identify the problem statement and apply ethics to** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to CAM profile diagrams	2
	PO 11	**Identify the problem statement for quality, budget, schedule** (mission requirement), to select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to CAM profiles	6
	PS O1	**Identify the problem statement** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	1
CO 6	PO 1	Formulate the problem statement and model the system for getting the solution of cams to regulate the speed of machines**using fundamentals of science &and engineering fundamentals.**	3
	PO 4	Understand the technical concepts of followers and interpret the equilibrium conditions for various applications for **complex engineering problems.**	5
	PO 12	Investigate and define a problem and identify constraints of mechanisms **environmental and sustainability limitations, health and safety and risk assessment issues** when dealing with performance of followers and their application on real world problems	4
	PSO 3	**Identify the problem statement** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	2

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 <$C \leq 40\%$ – Low/ Slight

2 - 40 % <$C < 60\%$ –Moderate

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**MECHANISMS and MACHINES**
	Mechanisms: Elements or links, classification, rigid link, flexible and fluid link, types of kinematic pairs types of constrained motion, kinematic chain, mechanism, machine, structure, inversion of mechanism, inversions of quadric cycle chain, single and double slider crank chains, mechanical advantage, Grubler's Criterion.
MODULE II	**KINEMATICS, PLANE MOTION OF BODY, ANALYSIS OF MECHANISMS**
	Kinematics: Velocity and acceleration, motion of link in machine, determination of velocity and acceleration, Graphical method, application of relative velocity method, plane motion of body: Instantaneous center of rotation, centroids and axodes, three centers in line theorem, graphical determination of instantaneous center, determination of angular velocity of points and links by instantaneous center method. Klein's construction, Coriolis acceleration, determination of Coriolis component of acceleration; Analysis of mechanisms: Analysis of slider crank chain for displacement, velocity and acceleration of slider, acceleration diagram for a given mechanism.
MODULE III	**STRAIGHT LINE MOTION MECHANISMS, STEERING GEARS, HOOKE'S JOINT**
	Straight-line motion Mechanisms: Exact and approximate copied and generated types, Peaucellier, Hart and Scott Russul, Grasshopper, Watt, TChebicheff and Robert mechanisms, pantograph. Steering gears: Conditions for correct steering, Davis Steering gear, Ackerman's steering gear, Hooke's joint: Single and double Hooke's joint, velocity ratio, application, problems.
MODULE IV	**CAMS, ANALYSIS OF MOTION OF FOLLOWERS**
	Cams: Definitions of cam and followers, their uses, types of followers and cams, terminology, types of follower motion, uniform velocity, simple harmonic motion and uniform acceleration; Maximum velocity and maximum acceleration during outward and return strokes in the above three cases; Analysis of motion of followers: Tangent cam with roller follower, circular arc cam with straight, concave and convex flanks
MODULE V	**HIGHER PAIRS, GEAR TRAINS**
	Higher Pairs: friction wheels and toothed gears, types, law of gearing, condition for constant velocity ratio for transmission of motion, velocity of sliding, form of teeth, cycloidal and involute profiles, phenomena of interferences, methods of interference; Condition for minimum number of teeth to avoid interference, expressions for arc of contact and path of contact of pinion and gear pinion and rack arrangements; Introduction to helical, bevel and worm gearing; Gear trains: Introduction, types, simple and reverted gear trains, epicyclic gear train; Methods of finding train value or velocity ratio of epicyclic gear trains, selection of gear box, differential gear for an automobile.

TEXTBOOKS

1. Amithab Ghosh, Asok Kumar Malik, "Theory of Mechanisms and machines", East West Press Pvt Ltd, 2001.
2. S.S Ratan, "Theory of Machines", Tata McGraw-Hill, 4th Edition, 2014
3. R. L. Norton, "Kinematics and Dynamics of Machinery", McGraw-Hill, 1st Edition, 2009.
4. P.L. Balleny, "Theory of Machines and Mechanisms", Khanna publishers, 2013.

REFERENCE BOOKS:

1. J. S. Rao, R.V. Dukkipati, "Mechanism and Machine Theory", New Age Publication, 1st Edition, 2013.
2. Uiker, Penock, Shigley, "Theory of Machines and Mechanisms", Oxford University Press, 4th Edition,2013.

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Introduction to kinematic pairs	CO1	T2 17.2
2	Determination of degree of freedom, problems.	CO2	T2 17.1
3	inversion of mechanism – inversions of quadric cycle chain, single and double slider crank chains .	CO2	T2 17.8
4	Mechanical Advantage and Grubler's Criterion	CO2	T2 17.6
5	Velocity of link in machine, Vector diagram for velocity.	CO1	T2 17.3
CONTENT DELIVERY (THEORY)			
6	Relative velocty method of four bar mechansim	CO2	T2 17.4
7	Relative velocty method of slider crank mechansim	CO3	T2 12.1
8	Determination of Velocity using Graphical method using relative velocity method.	CO3	T2 12.6
9	Acceleration of link in machine, Vector diagram for Acceleration.	CO3	T2 8.2
10	Watt, T.Chebicheff and Robert Mechanisms - Pantograph.	CO4	T2 8.9
11	Conditions for correct steering – Davis Steering gear, Ackerman's steering gear.	CO4	T2 15.1
12	Single and double Hooke's joint – Velocity Ratio – application – problems.	CO4	T2 15.8
13	Definitions of cam and followers, their uses	CO4	T2 15.9
14	Types of followers and cams, Terminology, Types of follower motion	CO5	T2 15.13
15	Uniform velocity, Simple harmonic motion	CO5	T2 13.12
16	Uniform acceleration. Maximum velocity and maximum acceleration during outward and return strokes in the various cases.	CO5	T2 13.11
17	Analysis of motion of followers: Tangent cam with Roller follower	CO5	T2 13.7

18	Cam mechanisms	CO5	T2 13.13
19	Synthesis of tangent cam	CO5	R3 16.12
20	Synthesis of circular arc cam	CO5	R3 16.18
21	Problems on Cam profiles	CO5	R3 16.21
22	Fundamentals of toothed gear	CO6	T2:16.1
23	Friction wheels and toothed gears and types of gears.	CO6	T2 16.3,4
24	Law of gearing -Condition for constant velocity ratio for transmission of motion - Velocity of sliding.	CO6	T2:16.5,6
25	Problems on toothed gears	CO6	T2:16.14
26	Form of teeth, cycloidal and involute profiles	CO6	R318.12
27	Phenomena of interferences – Methods of interference.	CO 5	T2:21.2
28	Condition for minimum number of teeth to avoid interference	CO 5	T2:21.1
29	Problems on Condition for minimum number of teeth to avoid interference	CO 5	T2:22.1
30	lenght of Path of contact	CO 5	T2:22.2
31	Length of Arc of contact	CO 5	R3 22.10
32	Contact ratio	CO 5	R322.4
33	Pinion and Rack arrangements	CO 5	R3 22.3
34	Introduction to Helical, Bevel and worm gearing.	CO 5	R3 22.13
35	Types of gears	CO 5	R3 22.12
36	Types of gear trains	CO6	T2.18.1
37	Epicyclic gear train.Methods of finding train value or velocity ratio of Epicyclic gear trains.	CO6	T2 18.6
38	Selection of gear box-Differential gear for an automobile.	CO6	R3 23.9
39	Problems on epicyclic gear train	CO6	R3 23.11
40	Tabular method	CO6	R3 23.4
41	Analytical method	CO6	R3 23.5
42	Equation of motion of gears	CO6	R3 23.12
43	Sun and Plant gears	CO6	R3 24.4
44	Annualr gear wheel	CO6	R3 24.5
45	Problems on sun and planet gear	CO6	R3 24.6
PROBLEM SOLVING/ CASE STUDIES			
46	Problems on annular gear.	CO6	R3 24.4
47	Problems on epicyclic gear train	CO6	R3 23.18
48	Applying velocity ratio in solving problems	CO6	R3 23.18
49	Law of gearing	CO6	R323.23
50	Applications of gear trains to real world problems	CO10	R3 23.14
51	Uniform velocity, Simple harmonic motion	CO5	T2 13.12
52	Uniform acceleration. Maximum velocity and maximum acceleration during outward and return strokes in the various cases.	CO5	T2 13.11
53	Analysis of motion of followers: Tangent cam with Roller follower	CO5	T2 13.7
54	Cam mechanisms	CO5	T2 13.13

55	Synthesis of tangent cam	CO5	R3 16.12
56	Synthesis of circular arc cam	CO5	R3 16.18
57	Problems on Cam profiles	CO5	R3 16.21
58	Fundamentals of toothed gear	CO6	T2:16.1
59	Friction wheels and toothed gears and types of gears.	CO6	T2 16.3,4
60	Law of gearing -Condition for constant velocity ratio for transmission of motion - Velocity of sliding.	CO6	T2:16.5,6
61	Problems on toothed gears	CO6	T2:16.14
DISCUSSION OF DEFINITION AND TERMINOLOGY			
62	Uniform velocity, Simple harmonic motion	CO5	T2 13.12
63	Uniform acceleration. Maximum velocity and maximum acceleration during outward and return strokes in the various cases.	CO5	T2 13.11
64	Analysis of motion of followers: Tangent cam with Roller follower	CO5	T2 13.7
65	Cam mechanisms	CO5	T2 13.13
66	Synthesis of tangent cam	CO5	R3 16.12
DISCUSSION OF QUESTION BANK			
1	Crank and Slotted lever mechanism, Degrees of freedom of various mechanisms	CO 1	R4:2.1
2	Velocity and acceleration diagrams by relative velocity method and I center method	CO 2	T4:7.3
3	Condition for correct steering, Davis steering gear mechanism	CO 3	R4:5.1
4	Cam profiles of knofe edge follower, roller follower and flat faced follower	CO 4	T1:7.5
5	Length of Path of contact, Length of arc of contact and contact ratio, speed of gears	CO 5,6	T1: 4.1

Signature of Course Coordinator **HOD,ME**

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

COURSE DESCRIPTION

Department	Mechanical Engineering				
Course Title	Applied Thermodynamics				
Course Code	AMEC13				
Program	B. Tech				
Semester	FOUR				
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	-	-
Course Coordinator	Mr. G Aravind Reddy, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB09	IV	Thermodynamics

II COURSE OVERVIEW:

Applied thermodynamics is the science of relationship between heat, work, and systems that analyze energy processes. The aim of this course is to apply the thermodynamic cycles, develop the power from a heat engines for various industrial and domestic applications. It makes use of the properties of thermodynamics to transform heat into work. Gasoline and diesel engines, jet engines, and steam turbines that generate electricity are all examples of heat engines. The proper understanding of compressors and refrigeration in various fields of engineering is addressed. Thus there is great relevance for this course for mechanical engineers.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Applied Thermodynamics	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	The concepts related to the operation of internal combustion engines based upon the fundamental engineering sciences of thermodynamics.
II	The techniques for improving the efficiencies and performance of compressors and refrigeration systems retained to practical applications such as irrigation, air conditioning and refining oil and gas..
III	The performance of Heat Engines in real-time applications by applying the various testing parameters of an engine.

VII COURSE OUTCOMES:

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

CO 1	**Classify** the fuel injection and ignition system to pretend the application of combustion chamber types such as T-head and overhead.	Understand
CO 2	**select** normal and abnormal combustion which affects the importance of flame front and flame propagation and knocking of engine variables	Remember
CO 3	**Experiment** with the testing and performance of an Internal combustion engine such as fuel consumption, power, efficiencies, and heat balance sheet.	Apply
CO 4	**Explain** the principle of operation related to the working of fan, blowers and compressors and their applications in industries/ factories and how do they differ with each other.	Understand
CO 5	**Solve** numerically related to the performance of all the variations in the velocity triangles pretended to single and multi-stage air compressors with industrial applications.	Apply
CO 6	**Outline** the basic concepts of refrigeration and vapor compression refrigeration systems with superheating and sub cooling to find out COP of refrigeration.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL

VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Formulate and evaluate concepts of thermo-fluid systems to provide solutions for inter disciplinary engineering applications sustainable designs for new generation automotive systems.	2	CIA/SEE

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Identify (knowledge) in suitable methods involved in basic components of an IC Engine and the working of a 2-stroke and 4- Stroke engines in solving (complex) engineering problems by applying the principles of **mathematics and engineering fundamentals.**	2
	PO 2	Understand the given **problem statement** related to the components of IC engine based on various **data collection** of parts related to the usage in 2-stroke and 4-stroke engines in **validating the experimental design solutions** and also **Interpretation of results.**	5
CO 2	PO 3	Identify the various normal and abnormal combustion which knocking using **analytical and mathematical process.**	3
CO 3	PO 1	Apply the basic **mathematical principles** used in formulation of **engineering problems**	3
	PO 2	Understand the testing and performance of an Internal combustion by **information and data collection** related to various parameters and validate the **experimental data** in a heat balance sheet documentation and also **Interpretation of results**	5

	PO 4	Understanding of an **ability to apply a systems approach to engineering problems** and ensuring the **quality issues** related to performance and also **ability to work with technical uncertainty** meeting the **industry standards** such as fuel consumption, power, efficiencies, and heat balance sheet.	4
	PSO 2	Formulate and evaluate concepts of thermo-fluid systems to **provide solutions** for inter disciplinary **engineering applications for** sustainable designs for new generation automotive systems.	2
CO 4	PO 1	Develop (knowledge, understand and apply) the basic tools used for **engineering problems** by applying the principles of **mathematics and engineering fundamentals.**	2
	PO 2	Identify the principle working of fan, blowers and compressors as well as material Selection and **identification model and validating the solutions** and also **Interpretation of results**	5
	PO 6	Understand the use of fan, blowers and compressors in industry usage and relevant legal requirements governing engineering activities, **including personnel, health, safety, and risk and for a high level of professional and ethical conduct in engineering.**	2
CO 5	PO 1	Explain understand the process parameter using complex the functions of engineering problems by applying the principles of **mathematics and engineering fundamentals.**	2
	PO 2	Categorize the concept of single and multi-stage compressors based upon the **data collection** with different **model transition to validate the solution** development for industrial applications.	4
CO 6	PO 1	Develop (knowledge, understand and apply) the basic tools used for **engineering problems** by applying the principles of **mathematics and engineering fundamentals.**	2
	PO 2	Identify the basic principles of refrigeration and identify the **problem statement and model** with VCRS system with the help of sub and super cooling and validate for a better feasible **solution development.**	4
	PO 3	**Understand the user needs of user-defined problems, use creativity** in building prototype applying the methods of model analyses **for innovative solutions, evaluate the outcomes to achieve engineering objectives.**	3
	PO 7	Explain the basic concepts of refrigeration and vapor compression refrigeration systems that **impact of the professional Engineering solutions in societal and Environmental contexts**	1

	PSO 2	Formulate and evaluate concepts of thermo-fluid systems to **provide solutions** for inter disciplinary **engineering applications for** sustainable designs for new generation automotive systems.	2

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	50.0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO 2	0	0	30.0	0	0	0	0	0	0	0	0	0	0	0	0
CO 3	66.7	50.0	0	36.6	0	0	0	0	0	0	0	0	0	66.6	0
CO 4	66.7	50.0	0	0	0	40.0	0	0	0	0	0	0	0	0	0
CO 5	66.7	40.0	0	18.0	0	0	0	0	0	0	0	0	0	0	0
CO 6	66.7	40.0	30.0	0	0	0	33.3	0	0	0	0	0	0	66.6	0

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 - $5 < C \leq 40\%$ – Low/ Slight

2 - $40\ \% < C < 60\%$ –Moderate

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
TOTAL	24	8	1	1	-	-	-	-	-	-	-	-	-	4	-
AVERAGE	3.0	2.0	1.0	1.0										2.0	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**IC ENGINES,FUEL INJECTION AND LUBRICATION SYSTEMS**
	I. C Engines: Four and two stroke engine, SI and CI engines, valve and port timing diagrams, fuel injection systems for SI engines, fuel injection systems for CI engines, ignition systems, cooling and lubrication system, fuel properties and combustion, Stoichiometry.
MODULE II	**COMBUSTION IN SI AND CI ENGINES**
	Combustion in SI engines and CI engines: Normal combustion and abnormal combustion, importance of flame speed and effect of engine variables, type of abnormal combustion, pre-ignition and knocking, fuel requirements and fuel rating, anti-knock additives, combustion chamber, requirements, types; Combustion in CI Engines: Four stages of combustion, delay period and its importance, effect of engine variables, diesel Knock, need for air movement, open and divided combustion chambers and nozzles used, fuel requirements and fuel rating
MODULE III	**TESTING AND PERFORMANCE,COMPRESSORS**
	Testing and performance: Parameters of performance, measurement of cylinder pressure, fuel consumption, air intake, exhaust gas composition, brake power, determination of frictional losses and indicated power, performance test, heat balance sheet and chart.Compressors: Classification, of compressors, fans, blower and compressor, positive displacement and dynamic types, reciprocating and rotary types.

MODULE IV	**ROTARY AND AXIAL CENTRIFUGAL COMPRESSORS**
	Rotary, dynamic and axial flow (positive displacement): Roots blower, vane sealed compressor, mechanical details and principle of working efficiency considerations; Centrifugal compressors: mechanical details and principle of operation, velocity and Pressure variation, Energy transfer, impeller blade shape-losses, slip factor, and power input factor, pressure coefficient and adiabatic coefficient, velocity diagrams, power; Axial flow compressors: Mechanical details and principle of operation, velocity triangles and energy transfer per stage degree of reaction, work done factor, isentropic efficiency, pressure rise calculations, polytropic efficiency.
MODULE V	**REFRIGERATION**
	Refrigeration: Mechanical refrigeration and types, units of refrigeration, air refrigeration system, details and principle of operation, applications of air refrigeration, vapour compression refrigeration systems, calculation of COP, effect of superheating and sub cooling, desired properties of refrigerants and common refrigerants, vapour absorption system, mechanical details, working principle, use of p-h charts for calculations.

TEXTBOOKS

1. V. Ganesan, "I.C. Engines", Tata McGraw-Hill, 3rd Edition, 2011
2. K. Rajput, "Thermal Engineering", Lakshmi Publications, 1st Edition, 2011.
3. B. John Heywood, "Internal Combustion Engine Fundamentals", Tata McGraw-Hill, 2nd Edition,2011.

REFERENCE BOOKS:

1. Mathur, Sharma, "IC Engines", DhanpatRai& Sons, 3rd Edition, 2008.
2. Pulkrabek, "Engineering Fundamentals of IC Engines", Pearson Education, 2nd Edition,2008.
3. Rudramoorthy, "Thermal Engineering", Tata McGraw-Hill, 5th Edition 2003.
4. C P. Arora, "Refrigeration and Air Conditioning", Tata McGraw-Hill Education,2013.

WEB REFERENCES:

1. https://nptel.ac.in/courses/thermal engineering

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=pages/btech-course-descriptions-iare-UG20

AKANKSHA lEARNING MANAGEMENT SYSTEM:

1. https://lms.iare.ac.in/index.php?route=account/login

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	References
OBE DISCUSSION			
1	Course Description on Outcome Based Education(OBE): Course Objectives ,Course Outcomes(CO),Program Outcomes(PO) and CO-PO Mapping	-	lms/ iare.ac.in
CONTENT DELIVERY (THEORY)			
2	Define Heat engine and working of SI and CI engines	CO 1	T2:2.3
3	Illustrate crank angle valve and port diagrams	CO 1	T1:2.6
4	Explain different Fuel injection and ignition systems for CI engines	CO 1	T2:2.22
5	Explain Cooling and Lubrication system	CO 1	T2:2.26 R1:2.55
6	Illustrate different fuels and its properties with their stoichiometry.	CO 1	T2:2.16 R1:2.61
7	Discuss phenomena of combustion process	CO 2	T2:2.30 R1:2.58
8-9	Emphasize Normal and abnormal combustion phenomena.	CO 2	T2:3.6 R1:4.29
10-11	Discuss Importance of flame speed and its effect on engine variables	CO 2	T2:3.14 R1:4.31
12	Demonstrate Knocking and its additives	CO 2	T2:3.14 R1:4.33
13-14	Illustrate different types of combustion chambers	CO 2	R1:4.36
15	Explain Four stages of combustion in C.I. Engines. Discuss delay period	CO 2	T2:3.18 R1:4.64
16-18	Discuss knocking and its effect on engine variables.	CO 2	T2:3.22
19	What is the need for air movement and discuss different combustion chambers.	CO 2	T2:3.28 R1:4.67
20-21	What are the fuel requirements, performance characteristics	CO 3	T2:4.2
22	Determination of frictional power, efficiency, brakes power.	CO 3	T1:4.8 R2:4.68
23	Discuss sankey diagram for heat balance sheet by means of losses.	CO 3	T2:4.15 R1:5.74
24	Performance analysis of IC engines and Classify compressors and types	CO 4	T1:4.12 R2:5.75
25	Explain the working of roots blower vane sealed compressor and its mechanisms and Mechanism details of centrifugal compressors	CO 4	T1:5.14 R1:6.78
26-28	Define power input factor, pressure coefficient and adiabatic coefficient	CO 4	T1:6.4 R2:6.8
29	Draw velocity diagrams and find power	CO 4	T2:7.7 R1:7.74

30-31	Discuss working principle of Axial flow compressor and find the efficiency and work done factor, isentropic, polytropic efficiency.	CO 5	T1:7.12 R2:8.75
32	Define refrigerating effect and its principle of operation and Air refrigeration system	CO 6	T1:9.14 R1:10.78
33	Discuss vapour compression system components and calculate cop.	CO 6	T1:10.4 R2:11.68
34	Explain vapour absorption system-mechanical details-working principle and Problems on p-h chart.	CO 6	T2:10.7 R1:12.74
35	Numerical problems: Testing and performance of engine parameters,Calculation of efficiencies of IC engine,heat balance sheet	CO 6	T1:1.5 R1:2.4
36	Single stage,multi and air compressor	CO 5	T1:2.5 R1:2.6
37	Velocity diagram for compressor	CO 5	T1:18.10 R1:17.7
38	Air refrigeration system	CO 6	T1:18.10 R1:17.7
39	Vapour compression refrigeration system	CO 5	T1:19.3 R1:18.2
40	Vapour absorption refrigeration system	CO 6	T1:19.5 R1:18.4
PROBLEM SOLVING/ CASE STUDIES			
41	Parameters of performance, measurement of cylinder pressure,	CO 3	T2:2.3
42	Parameters of performance, measurement offuel consumption	CO 3	T1:4.8 R2:4.68
43	Parameters of performance, measurement of air intake	CO 3	T1:4.12 R2:5.75
44	exhaust gas composition	CO 3	T1:4.8 R2:4.68
45	brake power	CO 3	T1:4.8 R1:5.72
46	determination of frictional losses and indicated power	CO 3	T1:5.14 R1:6.78
47	performance test	CO 3	T2:7.7 R1:7.74
48	heat balance sheet and chart	CO 3	T1:8.8 R1:8.73
49	mechanical details and principle of operation, velocity and Pressure variation,	CO 4	T1:12.4 R2:13.68
50	Energy transfer, impeller blade shape-losses, slip factor, and power input factor.	CO 5	T2:13.7 R1:14.74
51	pressure coefficient and adiabatic coefficient	CO 5	T2:9.19 R1:10.814
52	velocity diagrams, power; Axial flow compressors,Mechanical details and principle of operation	CO 5	T2:9.19 R1:10.814

53	velocity triangles and energy transfer per stage degree of reaction	CO 5	T1:10.4 R2:11.68
54	work done factor, isentropic efficiency	CO 5	T1:10.4 R2:11.68
55	work done factor, isentropic efficiency	CO 5	T2:10.7 R1:12.74
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Module I: IC engines,fuel injection and lubrication system	CO 1	T2:2.3
57	Module II: Combustion in SI and CI engines	CO 2	T2:3.14 R1:4.33
58	Module III:Testing and performance,Compressors	CO 3, CO 4	T2:4.2 R1:5.72
59	Module IV:Rotary and Axial Centrifugal Compressors	CO 5	T2:7.7 R1:7.74
60	Module V:Refrigeration	CO 6	T2:9.19 R1:10.814
DISCUSSION OF QUESTION BANK			
61	Module I: IC engines,fuel injection and lubrication system	CO 1	T2:2.3
62	Module II: Combustion in SI and CI engines	CO 2	T2:3.14 R1:4.33
63	Module III:Testing and performance,Compressors	CO 3, CO 4	T2:4.2 R1:5.72
64	Module IV:Rotary and Axial Centrifugal Compressors	CO 5	T2:7.7 R1:7.74
65	Module V:Refrigeartion	CO 6	T2:9.19 R1:10.814

Signature of Course Coordinator **HOD,ME**

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

COURSE DESCRIPTOR

Department	**MECHANICAL ENGINEERING**				
Course Title	**DESIGN OF MACHINE ELEMENTS**				
Course Code	AMEC14				
Program	B.Tech.				
Semester	IV				
Course Type	CORE				
Regulation	IARE -UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	–	–
Course Coordinator	Mr.B.Vijaya Krishna , Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC05	III	Solids Mechanics

II COURSE OVERVIEW:

Machine design emphasizes for influence the failsafe design in the mechanical systems using different theories of failure modes. The design of machine members focuses mainly on design of machine elements subjected to various types of loads and components include joints; Riveted, Welded, threaded joints, shafts and springs using Design standards, B.I.S codes of steels. The Design philosophy is based on strength, stiffness and material selection for manufacture of machine elements.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Design of Machine Elements	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
16.66%	Remember
33.34%	Understand
33.34%	Apply
16.66 %	Evaluate

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

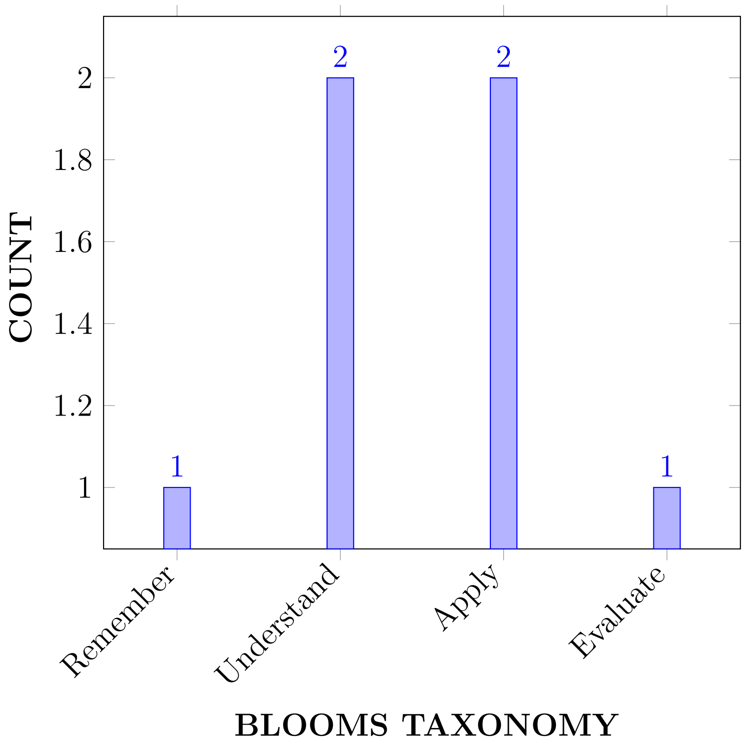
I	The machine element design process that achieves desired constraints for strength, rigidity and reliability
II	The nature of loading for the application of theories of failure for mechanical machine elements under different loading conditions.
III	The various permanent and temporary joints in engineering applications subjected to various loading conditions.
IV	The design procedure for the various power transmission elements on the basis of strength and rigidity

VII COURSE OUTCOMES:

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

CO1	**Outline** the knowledge of design process and design standards, theories of failures, analyses the stresses and strainsfor various machine elements.	Understand
CO2	**Develop** the Design procedure of riveted joints and welded joints for engineering applications like boilers, pressure vessels, ships and trusses.	Apply
CO3	**Classify** various types of keys and cotter joints used to employee secure to gears, pulleys, disc applications.	Understand
CO4	**Develop** the design procedures of knuckle joint for different loading conditions in propeller applications.	Apply
CO5	**Select** appropriate design procedures on the basis of strength, torsional rigidity for shafts and Couplings.	Remember
CO6	**Evaluate** the natural frequency, energy storage, stresses and deflections of helical springs for static and fatigue loadings.	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	3	Research papers / Industry exposure
PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	3	Research papers / Industry exposure

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Explain the importance of design process and theories failues solving through the scientific principles of **mathematics** and **science.**	2
CO 2	PO 1	Identify suitable permanent joints (Rivets, Welds) in engineering applications by applying the principles of **mathematics** and **engineering fundamentals.**	2
	PO 3	**Design Procedures** of **Riveted and Welded joint problems** with **various real time applications.**	3
	PSO 1	**Formulate** and **evaluate** engineering concepts of joints design to provide solutions for **various applications.**	3
CO 3	PO 1	Classify the different types of keys employed to various applications by applying the principles of **mathematics, sciece** and **engineering fundamentals.**	3
	PO 2	Apply the procedure of various loading on different cotter joints for **analyze** and **deriving related equations** from the provided information and substantiate with **interpretation** of **variations in the results**	4
CO 4	PO 1	Develop the theory, phenomena of Knucle joint for engineering applications by applying the principles of **mathematics, science** and **engineering fundamentals** to perform high efficiency.	3
	PO 3	**Design solutions** of **Knuckle joint problems** and **various loading conditions of each components** for different applications. .	4
	PSO 1	**Formulate** and **evaluate** engineering concepts of design to provide solutions for technology aspects in digital manufacturing.	2
CO 5	PO 1	Select the suitable shafts and couplings for numeraous engineering applications by applying the principles of **mathematics, science** and **engineering fundamentals** of design of machine elements.	3
	PO 3	**Design procedures** of **shafts** and **different strength conditions of** for various applications.	4
	PSO 1	**Formulate** and **evaluate** engineering concepts of shaft design to provide solutions for numerous applications.	2
	PSO 3	Make use of various **design tools** for**higher studies**in the field of design.	2
CO 6	PO 1	**Explain** the working principles of various springs and applying the principles of **mathematics, science** and **engineering fundamentals.** for derive the stress and deflection equations for helical and torsion springs	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Determine the given **spring problem statement** and**formulate** the deflection and energy storing capability for deriving related equations from the provided information and **interpretation** of **results.**	4
	PSO 1	**Formulate** and **evaluate** engineering concepts of torsion and helical springs design to provide solutions for technology aspects in digital manufacturing.	2
	PSO 3	Make use of various **design tools** for**higher studies**in the field of design.	2

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.6	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.6	-	30	-	-	-	-	-	-	-	-	-	100	-	-
CO 3	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	-	40	-		-	-	-	-	-	-	-	100	-	-
CO 5	100	-	40	-	-	-	-	-	-	-	-	-	100	-	100
CO 6	100	40	-	-		-	-	-	-	-	-		100	-	100

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 $< C \leq 40\%$ – Low/ Slight

2 - 40 % $< C < 60\%$ –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	-	3	-	-	-	-	-	-	-	-	-	3	-	-
CO 3	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	4	-		-	-	-	-	-	-		2	-	-
CO 5	3	-	4	-	-	-	-	-	-	-	-	-	2	-	2
CO 6	3	4	-	-	-	-	-	-	-	-	-		2	-	2
TOTAL	16	8	11	-	-	-	-	-	-	-	-	-	9	-	4
AVERAGE	2.66	4	3.66	-	-	-	-	-	-	-	-	-	2.25	-	2

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO THEORY OF FAILURES**
	Introduction: General considerations in the design of engineering materials and their properties, selection, manufacturing consideration in design, tolerances and fits, BIS codes of steels; Theories of failures, factor of safety design for strength and rigidity, preferred number; Fatigue loading : Stress concentration, theoretical stress concentration factor, fatigue stress concentration factor, notch sensitivity, design for fluctuating stresses, endurance limit, estimation of endurance strength, Goodman's life, Soderberg's line.
MODULE II	**DESIGN OF FASTENERS**
	Design of fasteners: Riveted joints, methods of failure of riveted joints, strength equations, efficiency of riveted joints, eccentrically loaded riveted joints; Welded Joints: Design of fillet welds, axial loads, circular fillet welds, bending, bolts of uniform strength.
MODULE III	**DESIGN OF KEYS AND JOINTS**
	Keys, cotters and knuckle joints: Design of keys, stress in keys, cotter joints, spigot and socket. Sleeve and cotter, jib and cotter joints, Knuckle joints
MODULE IV	**DESIGN OF SHAFTS**

	Design of Shafts: Design of solid and hollow shafts for strength and rigidity, design of shafts for complex loads, Shaft sizes, BIS code, design of shafts for gear and belt drives; Shaft couplings: Rigid couplings, muff, Split muff and flange couplings, flexible couplings, pin, bush coupling.
MODULE V	**DESIGN OF SPRINGS**
	Mechanical Springs: Stresses and deflections of helical springs, extension compression springs, springs for static and fatigue loading, natural frequency of helical springs, energy storage capacity, helical torsion springs, co-axial springs.

TEXTBOOKS

1. P. Kannaiah, "Machine Design", 2nd Edition, Scitech Publications India Pvt. Ltd, New Delhi, 2012 .

2. V.B. Bandari, "A Text Book of Design of Machine Elements", 3rd edition, Tata McGraw Hill, 2011.

REFERENCE BOOKS:

1. Richard G. Budynas, J. Keith Nisbett, "Shiegly's Mechanical Engineering Design", 10th Edition, 2014.

2. R.L. Norton, "Machine Design An Integrated approach", Person Publisher, 2nd Edition, 2006.

3. U.C. Jindal, "Machine Design", Pearson, 1st Edition, 2010.

4. R.S. Khurmi, A. K. Gupta,"Machine Design", S. Chand & Co, New Delhi, 1st Edition, 2014.

WEB REFERENCES:

1. http://nptel.ac.in/courses/Webcourse contents/IIT % 20 Kharagpur/Machine % 20design1/New index1.html

2. http://nptel.ac.in/downloads/112105125/

3. http:/alljntuworld.in/download/design machine members 1 dmm 1materials notes/

4. http:/scoopworld.in/2015/03/design of machine members dmm mech.html

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Introduction to Outcome Based Education		
CONTENT DELIVERY (THEORY)			
1	Introduction, General considerations in the design	CO 1	R4:1.5
2-3	Identify Engineering Materials and their properties. Tolerances and fits BIS codes of steels.	CO 1	T1:3.1 R3:3.16
4	Explain theories of failure	CO 1	T1:7.59
5-7	Explain Reversed Stresses	CO 1	T2:5.11

8	Explain Factor of safety, Design for strength and rigidity, preferred numbers	CO 1	T2:7.3 R3:3.21
9	Understand Stress concentration Theoretical stress Concentration factor Fatigue stress concentration factor Notch Sensitivity	CO 1	T1:7.63 R3:6.11
10-11	Explanation and problems on stress concentration. Endurance limit – Estimation of Endurance strength	CO 1	T1:7.89 R4:6.4
12-15	Explain Goodman's life – Soderberg's line. Solutions of problems on various types of loading.	CO 1	T1:7.9 R3:6.20
16-17	Compare Fasteners methods	CO 2	T1:11.2 R3:11.6
18	Explanation about Lap and but joints and various parameters involved in design of riveted joints.	CO 2	T1:9.2 R3:9.8
19	Understand efficiency of riveted joints Calculate stress induced in rivets	CO 2	T1:9.5 R3:9.14
20-21	Analyze Eccentrically loaded riveted joints. Problems in design of riveted joints.	CO 2	T2:8.3 R4:9.21
22-23	Understand design of fillet welds-axial loads-circular fillet welds	CO 2	T1:106 R4:10.17
24	Analyze Bending-bolts of uniform strength Construction design and proportions of bolts	CO 3	T1:11.9 R4:11.16
25	Explanation of various stresses induced in bolted joints and solution of problems in various applications	CO 3	T2:11.5 R4:11.10
26	Explanation of the procedure for finding size of bolts	CO 3	T2:11.9 R1:11.12
27	Bolted joints and associated parts for locking purpose	CO 3	T2:11.21 R1:11.7
28	Sketches for keys, cotters, knuckle joints and explanation of the purpose of each joint	CO 4	T1:12.1
29	Estimate Design of Keys, stress in keys	CO 7	T1:12.15 R3:12.7
30	Describe Cotter joints, Spigot and socket	CO 4	T2:9.9 R3:13.8
31-33	Compare Jib and cotter joints, knuckle joint	CO 4	T1:12:10 R3:12.4
34	Solution of problems under application load	CO 4	T1:12.16
35	Sketches of different couplings and various parameters to be explained	CO 4	T2:15.1 R3:14.16
36	Rigid couplings Muff, Split muff and Flange couplings	CO 4	T2:15.2. R2: 12.6
37	PIN-Bush coupling.	CO 4	T2:9.24 R2: 12.8
38	Problems of different couplings	CO 4	T2:9.30
39-41	Apply Formulas for determining size of both hollow and solid shafts and various conditions of loading for strength and Rigidity criteria	CO 5	T1:13.2 R3:14.6
42	Analyze Design of shafts for complex loads	CO 5	T1:13.8, R3:14.11

43-44	Distinguish Shaft size BIS codes. Applications and solution of problems for transmission of power by shafts loaded with belt and gear drives	CO 5	T1:13.9 R3:14:13
45	Sketches of different springs with relevant parameters Stresses and deflections of helical springs	CO 6	T2:16.2 R3:23.8
46	Extension compression springs-springs for static and fatigue loading	CO 6	T2:10.3 R4:23.18
47	Natural frequency of helical springs- energy storage capacity	CO 6	T2:10.5
48-49	Helical torsion springs	CO 6	T2:10.10
50-51	Co-axial springs.	CO 6	T1:10.15
52	Design of Helical Torsional Springs	CO 6	T2:10.21
PROBLEM SOLVING/ CASE STUDIES			
1	Problem Manufacutring Considerations	CO 1	R2:7.5
2	Problems on Theories of Failure	CO 1	R2:7.5
3	Problems on Factor of Safety	CO 1	R2:7.5
4	Problems on Notch Sensitivity	CO 1	R2:7.5
5	Problems on Rivit Efficiency	CO 2	R2:7.5
6	Problems on Soderberg's Line	CO 2	R2:7.5
7	Problems on Bolt Efficiency	CO 2	R2:7.5
8	Problems on Keys Strength	CO 3	R2:7.5
9	Problems on Cotter Joints	CO 3	R2:7.5
10	Problems on Knuckle Joint	CO 3	R2:7.5
11	Problems on Shaft	CO 4	R2:7.5
12	Problems on Couplings	CO 5	R2:7.5
13	Problems on Flange Couplings	CO 5	R2:7.5
14	Problems on Spring Strength	CO 6	R2:7.5
15	Problems on Torsional Springs	CO 6	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Definition and Terminology of Theory of Failures	CO 1	R4:2.1
2	Definition and Terminology of Various Fasternes	CO 2	R4:2.1
3	Definition and Terminology of Keys and Cotters	CO 3	R4:2.1
4	Definition and Terminology of Shafts	CO 4,5	R4:2.1
5	Definition and Terminology of Springs	CO 6	R4:2.1
DISCUSSION OF QUESTION BANK			
1	Discussion on Question Bank of Theory of Failures	CO 1	R4:2.1
2	Discussion on Question Bank of Various Fasternes	CO 2	R4:2.1
3	Discussion on Question Bank of Keys and Cotters	CO 3	R4:2.1
4	Discussion on Question Bank ofShafts	CO 4,5	R4:2.1
5	Discussion on Question Bank of Springs	CO 6	R4:2.1

Signature of Course Coordinator **HOD,ME**
Mr.B.Vijay Krishna, Assistant Professor

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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**Fluid Mechanics and Hydraulic Machines**				
Course Code	AMEC12				
Program	B.Tech				
Semester	IV				
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3		
Course Coordinator	Mr. A. Somaiah, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC01	II	Engineering Mechanics

II COURSE OVERVIEW:

This course is designed to provide students an understanding of characteristics of the fluids (liquids or gases) at rest as well as in motion. This branch of science deals with the static, kinematics and dynamic aspects of fluids. The proper understanding of mechanics of fluids is critical in various branches of engineering. The primary motive of this course is to examine, through the laws of fluid mechanics and thermodynamics, the means by which the energy transfer is carried out in the turbomachinery, together with the differing behavior of individual types in operation

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Fluid Mechanics and Hydraulic Machines	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
17%	Remember
50%	Understand
33%	Apply

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

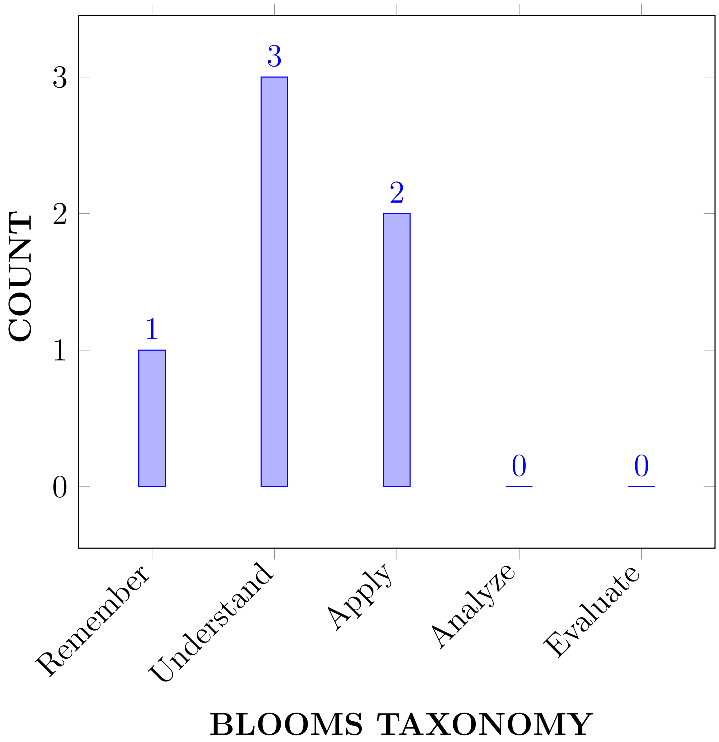
I	The fundamental knowledge of fluids, their properties and behavior under various conditions of closed conduit and external flow systems.
II	The development of various static and dynamic fluid flow governing equations from the fundamental conservation laws of motion studied under basic physics and classical Mechanics.
III	The application of boundary layer theory, Euler's equation, continuity and Impulse-momentum equation in fluid flows.
IV	The concepts of fluid mechanics and hydraulics to apply in real world engineering applications such as hydraulic turbines and pumps in power stations.

VII COURSE OUTCOMES:

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

CO 1	**Relate** the basic properties, various types and patterns of fluid flow configurations that are encountered in fluid flows.	Remember
CO 2	**Apply** the basic laws of conservation for various phenomena of fluid flow systems by understanding appropriate parametric assumptions and limitations.	Apply
CO 3	**Outline** the regimes and separation of boundary layer during external fluid flow systems.	Understand
CO 4	**Compare** the total and hydraulic gradient lines for distinct cases of losses during a closed conduit fluid flow systems.	Understand
CO 5	**Demonstrate** the theories, cavitation phenomena and working principles of hydraulic turbines.	Understand
CO 6	**Make use of** the dimensionless parameters, model analysis to analyze prototypes of hydraulic pumps.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety.	2	CIE/Quiz/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	Assignments/ SEE /CIE, AAT, QUIZ
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	3	Research papers / Group discussion / Short term courses

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Identify** the basic properties, various types, patterns of fluid flow configurations to a considerable extent and appreciate their importance and applicability in solving complex fluid flow engineering problems by **applying** the principles of mathematics and science.	2
CO 2	PO 1	**Apply** the basic conservation laws of science for various phenomena of fluid systems and use mathematical principles for deriving complex fluid flow engineering equations by understanding the appropriate parametric assumptions and limitations based on engineering fundamentals of fluid mechanics.	3
	PO 2	**Understand** the given problem statement and **formulate** complex fluid flow engineering phenomena and system for **deriving** various governing equations of fluid mechanics from the provided information and substantiate with the **interpretation** of variations in the results.	4
	PSO 3	**Make use of** computational and **experimental** tools for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of fluid mechanics.	2
CO 3	PO 1	**Relate** the knowledge of flow regimes, separation of boundary layer during external fluid flow in complex engineering problems by **applying** the principles of mathematics, science and fluid engineering fundamentals.	2
	PO 2	**Understand** the given problem statement and **formulate** boundary layer phenomena of external fluid flow engineering problems from the provided information and data in reaching substantiated **conclusions** by the **interpretation** of results.	4

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 4	PO 1	**Apply** the basic conservation laws of science for various phenomena of fluid systems and use mathematical principles for **deriving** complex fluid flow engineering equations by **understanding** the appropriate parametric assumptions and limitations based on closed conduit flow for minimum losses.	3
	PO 2	**Understand** the given problem statement and **formulate** complex fluid flow engineering phenomena and system for **deriving** various **governing** equations of fluid flow through the pipes from the provided information.	4
	PO 3	**Identify, formulate and analyse** the total and hydraulic gradient lines for different cases of losses and **apply** in closed conduit flows.	4
	PO 12	**Recognize** the need for and ability to **engage** in independent and life-long learning in the broadest context of technological change and **interpretation** of closed conduit flows.	3
CO 5	PO 1	**Apply** the basic principles of science for various phenomena of fluid systems and use mathematical principles for **deriving** the equations for power generation through the turbines by **understanding** the assumptions and limitations of fluid machines.	3
	PO 2	**Understand** the given problem statement and **formulate** fluid flow engineering phenomena and system for **deriving** various governing equations of fluid flow machines from the provided information.	3
	PO 4	**Identify, formulate** and **analyse** the theories, cavitation phenomena in case of reaction turbines and **interpret** and **estimate** the characteristics of a drafttube.	5
	PO 12	**Recognize** the need for and ability to **engage** in independent and life-long learning in the broadest context of technological change of hydraulic turbines with repect to **estimation** and **innovation** in the design, development point of view.	4
	PSO 3	**Formulate** and **evaluate** engineering concepts of hydraulic turbines, drafttubes for the resolution towards the innovative design to meet eco, societal needs.	2
CO 6	PO 1	**Apply** the principles of science for various phenomena of fluid pumps and use mathematical principles for **deriving** the equations for power transmission through the pipes by **understanding** the assumptions and limitations of fluid machines.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Use research based knowledge, **identify, formulate and analyse** the data relating to dimensionless parameters, model analysis to **draw** prototype models **interpret** the different real and prototype models.	6
	PO 3	**Design** solutions for complex engineering problems and **design system components**or pumps to **achieve** the requirement of specified needs with appropriate consideration for the **development** of different kinds of pumps proper **validation** and **justification**.	6
	PO 4	Use research-based knowledge including **design** of **experiments**, **analysis** and **interpretation** of data to provide **valid** information **relating** to model analysis, dimensionless parameters, pumps to **derive** equivalent expression prototypes.	7
	PO 12	**Identify, formulate and analyse** dimensionless parameters, prototype models utilizing cavitation phenomena to **interpret** the characteristics of distinct pumps.	4
	PSO 3	**Make use of** computational and experimental tools for building career paths towards **innovation**, startups, employability in the field of fluid power engineering.	2

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	40	-	-	-	-	-	-	-	-	-	-	-	-	100
CO 3	66.7	40	-	-	-	-	-	-	-	-	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 4	100	40	40	-	-	-	-	-	-	-	-	37.5	-	-	-
CO 5	100	30	-	45	-	-	-	-	-	-	-	50	-	-	100
CO 6	100	60	60	63.6	-	-	-	-	-	-	-	50	-	-	100

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	3
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	1	-	-	-	-	-	-	-	-	1	-	-	-
CO 5	3	1	-	2	-	-	-	-	-	-	-	2	-	-	3
CO 6	3	2	2	3	-	-	-	-	-	-	-	2	-	-	3
TOTAL	18	6	3	5	-	-	-	-	-	-	-	5	-	-	9
AVERAGE	3	1	1.5	2.5	-	-	-	-	-	-	-	1.66	-	-	3

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	Concept Video	✓	Tech talk	✓
Assignments	-	Open Ended Experiments	✓	-	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**FLUID STATICS**
	Definition of fluid, Newtons law of viscosity, Units and dimensions-Properties of fluids, mass density, specific volume, specific gravity, viscosity, compressibility and surface tension, application of continuity equation.
MODULE II	**FLUID KINEMATICS AND DYNAMICS**
	Fluid Kinematics: Kinematics of fluid flow- Eulerian and Lagrangian descriptions, Stream line, path line, streak line and stream tube, classification and description of flows for one and three dimensions. Fluid Dynamics: Eulers equation of motion, Bernoulli equation for flow along a stream line and applications, Measurement of flow and momentum equation.
MODULE III	**BOUNDARY LAYER CONCEPTS AND CLOSED CONDUIT FLOW**
	Concept of boundary layer – Definition, characteristics along thin plate, laminar, transition and turbulent boundary layers, separation of boundary layer, measures of boundary layer thickness. Closed conduit flow: – Darcy Weisbach equation, friction factor, Head loss in pipe flow, Moodys diagram and introduction to dimensional analysis.
MODULE IV	**FLUID MACHINES**
	Classification of water turbines, heads and efficiencies, velocity triangles-Axial, radial and mixed flow turbinesPelton wheel, Francis turbine and Kaplan turbines, working principles – draft tube- Specific speed,unit quantities, performance curves for turbines – governing of turbines.
MODULE V	**PUMPS**
	Theory of rotodynamic machines, various efficiencies, velocity components at entry and exit of the rotor, velocity triangles, Centrifugal pumps, working principle, work done by the impeller, performance curves– Cavitation in pumps- Reciprocating pump–working principle-indicator diagrams.

TEXTBOOKS

1. Rajput, "Fluid Mechanics and Hydraulic Machines", S.Chand. Co, 6th Edition, 1998.
2. H Modi, Seth, "Hydraulics, Fluid Mechanics and Hydraulic Machinery", Rajsons Publications, 20th Edition, 2013.
3. M. White, Fluid Mechanics, 8th Edition, Tata McGraw Hill, 2016

REFERENCE BOOKS:

1. D.S. Kumar, "Fluid Mechanics and Fluid Power Engineering", Kotaria and Sons, 9th Edition 2013.
2. Dr. R K Bansal, "A Text Book of Fluid Mechanics and Hydraulic Machines", Laxmi Publications, 9th Edition, 2015.
3. R. L. Panton, Incompressible Flow, Wiley-India, 3rd Edition, 2005.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112105171/
2. https://www.oreilly.com/library/view/fluid-mechanics-and/9788177583649/

COURSE WEB PAGE:

https://www.iare.ac.in/sites/default/files/UG20/Fluid_Mechanics_and_Hydraulic_Machines.pdf

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Introduction to Outcome Based Education		
CONTENT DELIVERY (THEORY)			
2	Definition of fluid, Newtons law of viscosity	CO 1	T2:2.3
3	Units and dimensions-Properties of fluids	CO 1	R1:2.6
4	Mass density, specific volume and specific gravity	CO 1	T1:2.6
5	Viscosity and its types.	CO 1	T2:2.7 R1:2.18
6	Compressibility and its applications	CO 1	T2:2.22
7	Surface Tension	CO 1	T2:2.25
8	Application of continuity equation.	CO 1	T3:3.6.7
9	Fluid Kinematics: Kinematics of fluid flow- Eulerian and Lagrangian descriptions	CO 2	T2:2.22
10	Stream line, path line	CO 2	T2:2.2
11	Streak line and stream tube	CO 2	T1:4.8 R2:4.68
12-13	Classification and description of flows for one and three dimensions.	CO 2	T1:4.12 R2:5.75
14	Introduction to fluid dynamics	CO 2	T2:2.26 R1:2.55
15-16	Eulers equation of motion, Bernoullis equation for flow along a stream line and applications	CO 2	T3:4.162
17-18	Measurement of flow and momentum equation.	CO 2	T3:4.162
19	Introduction to boundary layer theory	CO 3	T2:3.14 R1:4.33
20	Definition, characteristics along thin plate	CO 3	R1:4.36
21	Laminar, transition and turbulent boundary layers	CO 3	T2:3.22
22-23	Separation of boundary layer, measures of boundary layer thickness.	CO 3	T2:3.28 R1:4.67
24	Closed conduit flow: – Darcy Weisbach equation	CO 4	T2:4.2

25	Moodys diagram and introduction to dimensional analysis	CO 4	T2:4.3 R1:4.71
26	Introduction to hydraulic machines.	CO 5	T1:4.8 R1:5.72
27	Classification of water turbines, heads and efficiencies	CO 5	T1:5.8 R1:5.73
28-29	Velocity triangles of turbines	CO 5	T1:5.14 R1:6.78
30	Point and distributed loads.	CO 5	T2:5.19 R1:6.81
31	Axial, radial and mixed flow turbines	CO 5	T1:6.4 R2:6.8
32-33	Pelton wheel, Francis turbine working principles	CO 5	T2:7.7 R1:7.74
34	Kaplan turbines, working principles, draft tube.	CO 5	T1:7.12 R2:8.75
35	Introduction to pumps	CO 6	T1:7.8 R1:8.72
36	Theory of rotodynamic machines, various efficiencies	CO 6	T1:8.8 R1:8.73
37	Velocity components at entry and exit of the rotor	CO 6	T1:9.14 R1:10.78
38	Velocity triangles	CO 6	T2:9.19 R1:10.814
39	Centrifugal pumps, working principle, work done by the impeller	CO 6	T1:10.4
40	Performance curves– Cavitation in pumps	CO 6	T2:10.7 R1:12.74
41	Reciprocating pump–working principle	CO 6	T1:11.12 R2:12.75
42	Indicator diagrams.	CO 6	T1:12.4
PROBLEM SOLVING/ CASE STUDIES			
1	Specific gravity	CO 1	T1:2.6
2	Viscosity	CO 1	T2:2.7 R1:2.18
3	Surface tension	CO 1	T2:2.22
4	Compressibility	CO 1	T3:3.6.7
5	Flow lines	CO 2	T2:2.26 R1:2.55
6	Stream Function	CO 2	T3:4.162
7	Bernoullis equation	CO 2	T3:4.162
8	Laminar boundary layer	CO 3	R1:4.36
9	Turbulent boundary layer	CO 3	T2:3.18 R1:4.64
10	Darcy weisbach equation	CO 4	T2:3.22

11	Pelton wheel turbine	CO 3	T2:3.28 R1:4.67
12	Francis turbine	CO 5	T1:5.14 R1:6.78
13	Kaplan turbine	CO 5	T1:7.12 R2:8.75
14	Centrifugal Pumps	CO 6	T2:9.19 R1:10.814
15	Reciprocating pumps	CO 6	T2:10.7 R1:12.74
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Module I: Fluid Statics	CO 1	T2:2.3
2	Module II: Fluid Kinematics and Dynamics	CO 2	T2:3.14 R1:4.33
3	Module III:Boundary Layer Concepts and Closed Conduit Flow	CO 3, CO 4	T2:4.2 R1:5.72
4	Module IV:Fluid Machines	CO 5	T2:7.7 R1:7.74
5	Module V:Pumps	CO 6	T2:9.19 R1:10.814
DISCUSSION OF QUESTION BANK			
1	Module I: Fluid Statics	CO 1	T2:2.3
2	Module II: Fluid Kinematics and Dynamics	CO 2	T2:3.14 R1:4.33
3	Module III:Boundary Layer Concepts and Closed Conduit Flow	CO 3, CO 4	T2:4.2 R1:5.72
4	Module IV:Fluid Machines	CO 5	T2:7.7 R1:7.74
5	Module V:Pumps	CO 6	T2:9.19 R1:10.814

Signature of Course Coordinator **HOD, ME**

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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**MANUFACTURING PROCESSES**				
Course Code	**AMEC11**				
Program	B.Tech				
Semester	IV				
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. C Labesh Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC02	II	Manufacturing Practice

II COURSE OVERVIEW:

The primary objective of this course is to introduce the concept of manufacturing technology with the help of various processes widely employed in industries. The course consists of casting, welding, sheet metal forming, extrusion and forging processes with the related details of equipment and applications. Introduces the different manufacturing processes and breakeven analysis. Engineering materials, laying emphasis on ferrous and non-ferrous materials along with the heat treatment of metals. Discusses the special casting processes and metal-forming processes respectively.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Manufacturing Processes	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

Alternative Assessment Tool (AAT)

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

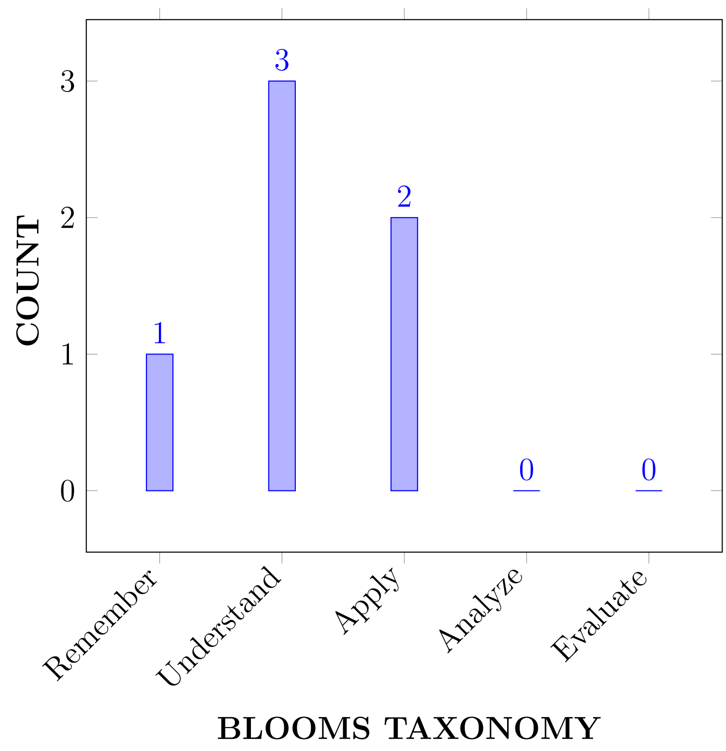
I	The Importance of manufacturing sciences in the day-to-day life, and study the basic manufacturing processes and tools used.
II	The knowledge in thermal, metallurgical aspects during casting and welding for defect free manufacturing components.
III	Design features that make each of these manufacturing process both harder, easier, assess design and manufacturing features on real products.

VII COURSE OUTCOMES:

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

CO 1	**Outline** the steps involved in making a casting the desired pattern for automotive industry components cylinder heads, engine blocks etc.	Remember
CO 2	**Categorize** various defects and shortcomings during gas welding operation such as TIG, MIG and Spot welding etc. for real time applications.	Understand
CO 3	**Illustrate** the properties and bonding techniques of plastics for various plastic molding techniques.	Understand
CO 4	**Apply** the appropriate metal forming techniques, for producing components like hexagonal bolt, nut etc.	Apply
CO 5	**Explain** the working principle of hot and cold extrusion processes and their application in industries for making of pipes and tubes.	Apply
CO 6	**Classify** the various forging techniques based on functionality, cost and time in development of critical products.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	2	AAT
PSO 2	Focus on ideation and research towards product development using additive manufacturing, CNC simulation and high speed machining.	2	AAT
PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2	AAT

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals.**	2
CO 2	PO 4	Investigate prototype models based on constraint including **Environmental sustainability, Health and safety risks assessment issues** and define specific problem.	2
CO 3	PO 3	**Identify** the various properties of Bonding techniques using **analytical and mathematical process.**	3
CO 4	PO 2	Make use of the metal forming techniques used in **Design, Model Creation and Validation of component Parts by Problem Analysis.**	4
	PO 3	Understand the given **problem statement** related to their working principle and based upon type of **manufacturing process.**	4
	PSO 3	Build practical experience in building the real time products, using **industry standard tools and collaboration technique** in the field of Manufacturing System.	2
CO 5	PO 1	Apply the basic **mathematical principles.**used in formulation of **engineering problems**	2
	PO 2	Understand the working principle used in Hot and Cold Working Process by **Natural Science and Engineering Sciences.**	2
	PSO 3	Identify the principle involved in Hot and Cold Extrusion process by **Qualitative and Quantitative methods** to their engineering problems.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	PO 1	Explain (understand) the process parameter using (complex) the functions of engineering problems by applying the principles of **mathematics and engineering fundamentals.**	
	PO 2	**Categorise** the concept of Forging Techniques based upon the **information and data collection in engineering problems.**	4

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	-	-	-	18.1	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	30.	-	-	-	-	-	-	-	-		-	-	-
CO 4	-	40	20	-	-	-	-	-	-	-	-	-	-	-	100
CO 5	66.7	20	-	-	-	-	-	-	-	-	-		-	-	100
CO 6	66.7	40	-	-	-	-	-	-	-	-	-	-	-		-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**CASTING**
	Casting: Steps involved in making a casting, its applications, patterns and types of patterns, pattern allowances and their construction, types of casting processes, solidification of casting.
MODULE II	**WELDING**
	Welding: Welding types, Oxy-fuel gas welding, cutting, standard time and cost calculations, arc welding Process, forge welding, resistance welding, thermit welding. Inert gas welding, TIG welding, MIG welding, friction welding, induction pressure welding, explosive welding, electron beam welding, laser welding, soldering and brazing. Heat affected zone in welding, welding defects, causes and remedies, destructive and non-destructive testing of welds.
MODULE III	**METAL FORMING**
	Forming: Hot working, cold working, strain hardening, recovery, re-crystallization and grain growth, comparison of properties of cold and hot worked parts, rolling fundamentals, theory of rolling, types of rolling mills and products; Forces in rolling and power requirements, stamping, forming and other cold. Working processes: Blanking and piercing, bending and forming, drawing and its types, wire drawing and tube drawing; coining; hot and cold spinning, types of presses and press tools, forces and power requirements for the above operations.

MODULE IV	**EXTRUSION AND RAPID PROTOTYPING**
	Extrusion of Metals: Basic extrusion process and its characteristics, hot extrusion and cold extrusion, forward extrusion and backward extrusion, impact extrusion, extruding equipment, tube extrusion and Pipe making, hydrostatic extrusion, forces in extrusion; Additive manufacturing: Rapid prototyping and rapid tooling.
MODULE V	**FORGING**
	Forging processes: Forging operations and principles, tools, forging methods, Smith forging, drop forging, roll forging, forging hammers: Rotary forging, forging defects, cold forging, swaging, forces in forging operations.

TEXTBOOKS

1. Kalpakjian and Schmid, Manufacturing processes for engineering materials -Pearson India, 5 th Edition 2014.

REFERENCE BOOKS:

1. Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems John Wiley and Sons Inc., 4th Edition, 2008.
2. Degarmo, Black and Kohser, Materials and Processes in Manufacturing (9th Edition) John Wiley and Sons Inc 7 th Edition, 2012.

WEB REFERENCES:

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

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	References
	OBE DISCUSSION		
1	Course Description on Outcome Based Education(OBE): Course Objectives ,Course Outcomes(CO),Program Outcomes(PO) and CO-PO Mapping	-	lms/ iare.ac.in
	CONTENT DELIVERY (THEORY)		
2	Introduction to manufacturing processes.	CO 1	T2:2.3
3	Review on casting and pattern	CO 1	T1:2.6
4	Discuss the casting processes and their types.	CO 1	T2:2.22
5	Describe the solidification of casting	CO 1	T2:2.26 R1:2.55
6	Describe the welding techniques.	CO 1	T2:2.16 R1:2.61
7	Discuss the effect of TIG and MIG welding	CO 2	T2:2.30 R1:2.58
8-9	Discuss the effect of Heat affected zone in welding.	CO 2	T2:3.6 R1:4.29
10-11	Discuss the welding defects	CO 2	T2:3.14 R1:4.31

12	Discuss the causes and remedies.	CO 2	T2:3.14 R1:4.33
13-14	Introduction to destructive and non-destructive testing of welds.	CO 2	R1:4.36
15	Classifying and Demonstration of metal forming.	CO 2	T2:3.18 R1:4.64
16-18	Discuss the hot and cold workin.	CO 2	T2:3.22
19	Discuss the strain hardening recovery and recrystallizationUnilateral and bilateral tolerance system, hole and shaft basis systems, Interchangeability and selective assembly.	CO 2	T2:3.28 R1:4.67
20-21	Comparison of properties of cold and hot worked parts.	CO 3	T2:4.2
22	Introduction to rolling.	CO 3	T1:4.8 R2:4.68
23	Demonstration of working of rolling operations.	CO 3	T2:4.15 R1:5.74
24	Classifying rolling types	CO 4	T1:4.12 R2:5.75
25	Introduction to mills and products and stamping.	CO 4	T1:5.14 R1:6.78
26-28	Demonstration of forces in rolling and their calculations.	CO 4	T1:6.4 R2:6.8
29	Discuss stamping forming and other cold operations.	CO 4	T2:7.7 R1:7.74
30-31	Explanation of blanking and piercing operations.	CO 5	T1:7.12 R2:8.75
32	Introduction to drawing and its types.	CO 6	T1:9.14 R1:10.78
33	Discuss the wire and tube drawing techniques	CO 6	T1:10.4 R2:11.68
34	Explain extrusion of metals.	CO 6	T2:10.7 R1:12.74
35	Describe the importance of impact and extruding equipment	CO 6	T1:1.5 R1:2.4
36	Describe hydrostatic extrusion, forces in extrusion	CO 5	T1:2.5 R1:2.6
37	Introduction to Additive manufacturing	CO 6	T1:18.10 R1:17.7
38	Describe the Smith forging, drop forging	CO 6	T1:18.10 R1:17.7
39	Discuss the rotary forging, forging defects	CO 6	T1:19.3 R1:18.2
40	Describe the cold forging, swaging, forces in forging operations	CO 6	T1:19.5 R1:18.4
PROBLEM SOLVING/ CASE STUDIES			
41	Parameters of performance, measurement of cylinder pressure,	CO 3	T2:2.3

42	Parameters of performance, measurement offuel consumption	CO 3	T1:4.8 R2:4.68
43	Parameters of performance, measurement of air intake	CO 3	T1:4.12 R2:5.75
44	exhaust gas composition	CO 3	T1:4.8 R2:4.68
45	brake power	CO 3	T1:4.8 R1:5.72
46	determination of frictional losses and indicated power	CO 3	T1:5.14 R1:6.78
47	performance test	CO 3	T2:7.7 R1:7.74
48	heat balance sheet and chart	CO 3	T1:8.8 R1:8.73
49	mechanical details and principle of operation, velocity and Pressure variation,	CO 4	T1:12.4 R2:13.68
50	Energy transfer, impeller blade shape-losses, slip factor, and power input factor.	CO 5	T2:13.7 R1:14.74
51	pressure coefficient and adiabatic coefficient	CO 5	T2:9.19 R1:10.814
52	velocity diagrams, power; Axial flow compressors,Mechanical details and principle of operation	CO 5	T2:9.19 R1:10.814
53	velocity triangles and energy transfer per stage degree of reaction	CO 5	T1:10.4 R2:11.68
54	work done factor, isentropic efficiency	CO 5	T1:10.4 R2:11.68
55	work done factor, isentropic efficiency	CO 5	T2:10.7 R1:12.74
DISCUSSION OF DEFINITION AND TERMINOLOGY			
61	Module I: Casting	CO 1	T2:2.3
62	Module II: Welding	CO 2	T2:3.14 R1:4.33
63	Module III:Metal Forming	CO 3, CO 4	T2:4.2 R1:5.72
64	Module IV:Extrusion and Rapid Prototyping	CO 5	T2:7.7 R1:7.74
65	Module V:Forging	CO 6	T2:9.19 R1:10.814
DISCUSSION OF QUESTION BANK			
61	Module I: Casting	CO 1	T2:2.3
62	Module II: Welding	CO 2	T2:3.14 R1:4.33

63	Module III:Metal Forming	CO 3, CO 4	T2:4.2 R1:5.72
64	Module IV:Extrusion and Rapid Prototyping	CO 5	T2:7.7 R1:7.74
65	Module V:Forging	CO 6	T2:9.19 R1:10.814

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**Fluid Mechanics and Hydraulic Machines Laboratory**				
Course Code	AMEC16				
Program	B.Tech				
Semester	Four				
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Mr. A. Somaiah, Assistant Professor				

I COURSE OVERVIEW:

The Fluid Machanics and Hydraulics Machines Laboratory is intended to observe the properties of fluids and to conduct experiments involving both incompressible and compressible flow. This course enables to apply the laws of fluid mechanics and thermodynamics, the means by which the energy transfer is carried out in the turbomachinery. It includes the flow measuring devices, study of performance characteristic curves of equipment and techniques of fluid mechanics to know how the fluid is going to move or operate.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC01	II	Engineering Mechanics

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Fluid Machanics and Hydraulics Machines Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks 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 labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

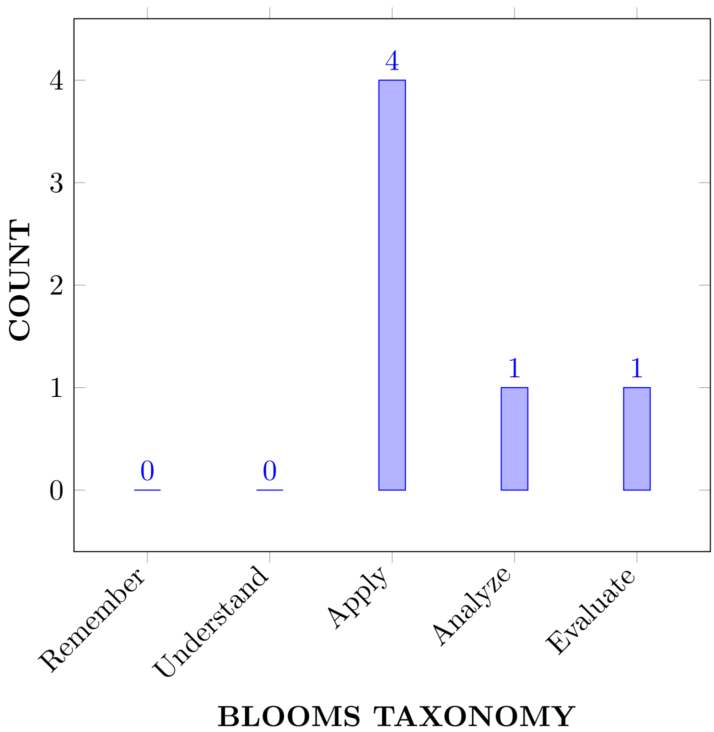
I	The types of fluids, properties and behaviour under static and dynamic conditions of closed conduit and external flow systems.
II	The operating principle of various turbo machinery and analyze their performance characteristics under various operating conditions.
III	The measurement of flow rate through various internal and external flow systems.

VII COURSE OUTCOMES:

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

CO 1	**Utilize** the concept of calibrating Orifice and Venturi meter to reduce the uncertainty in the discharge coefficient.	Apply
CO 2	**Make use of** the pipe friction apparatus, determine the coefficient of friction interpreting data from Moody's diagram to identify, name, and characterize flow patterns and regimes.	Apply
CO 3	**Apply** the statement of Bernoulli's equation in real fluids to demonstrate whether the total energy of flow is constant.	Apply
CO 4	**Distinguish** the performance characteristics of turbo machinery for various operating conditions.	Analyze
CO 5	**Apply** the concepts of intercooling in multistage air compressor for minimum power input.	Apply
CO 6	**Determine** the performance parameters of internal combustion engines under variable input conditions for optimum fuel consumption.	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises/CIA/SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	Lab Exercises/CIA/SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations.	1	Lab Exercises/CIA/SEE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	**Utilize** the concept of calibration to a considerable extent appreciate their importance and **applicability** in solving fluid flow engineering problems by **applying** the principles of Mathematics and Engineering	3
	PO 3	**Understand** the given problem statement, **calibration** procedure, provided information and data in reaching substantiated conclusions by the **interpretation** of results.	3
	PSO 3	**Make use of** multi physics, computational fluid dynamics and simulation tools for building career paths towards innovative startups, employability in the field of fluid flow analysis.	3

CO 2	PO 1	**Explain** various effects of viscosity in flow through pipes and **apply** Newtons law of viscosity, in **calculating** energy loss by applying principles of Mathematics, Science and Engineering	3
	PO 5	**Understand** the given problem statement, effects of viscosity, and capillary rise for the bodies immersed in fluids. (from the provided information) in **solving** analysis problems.	2
	PSO 3	**Apply** the knowledge Newtons law of viscosity in understanding the body, under different inlet conditions in **solving** flow through pipes by applying the principles of Mathematics, Science and Engineering	2
CO 3	PO 1	**Summarize** the concept of pressure measuring devices applications, effect of buoyancy on submerged bodies, their importance and **applicability** in solving fluid flow engineering problems by applying the principles of mathematics, science and engineering	2
	PO 3	**Understand** the given problem statement and **formulate** of Bernoullis equation and its **applications** in **solving** fluid flow engineering problems and **interpretation** of variations in the results.	5
	PSO 3	**Apply** knowledge of various effects of viscosity, static pressure, surface tension, Newton's law of viscosity, pressure difference and capillary rise in **deriving** and solving fluid flow problems.	2
CO 4	PO 1	**Recognize** the importance and application of dimensions, units and dimensional homogeneity in **solving** engineering problems with specific emphasis to fluid mechanics by **applying** the principles of mathematics, science and engineering	3
	PO 5	**Understand** the given problem statement and **formulate** the dimensional analysis and similarity parameters for predicting physical parameters that govern fluid systems in **designing** prototypes devices.	3
	PSO 3	**Apply** concept of dimensional analysis and similarity parameters for **predicting** physical parameters for the fluid flow analysis used in designing prototypes devices for solving design problems.	2
CO 5	PO 1	**Apply** the basic conservation laws of science for various phenomena of fluid systems and use mathematical principles for **deriving** fluid flow engineering equations by understanding the appropriate parametric assumptions and limitations based on engineering fundamentals of fluid mechanics.	2
	PO 3	**Understand** and **formulate** complex fluid flow engineering phenomena and system for **deriving** various governing equations of fluid mechanics from the provided information and **interpretation** of variations in the results.	4

	PO 5	**Make use of** computational and **experimental** tools for **creating** innovative career paths, to be an entrepreneur and desire for higher studies in the field of fluid mechanics.	3
	PSO 3	**Apply** the concept of dimensional analysis and similarity parameters for **predicting** physical parameters for the fluid flow analysis used in designing prototype devices to solve fluid flow problems.	2
CO 6	PO 1	**Apply** the knowledge of mathematics and engineering fundamentals principles to **understand** the Bernoulli equation for real flows and its applications.	2
	PO 3	**Apply** Euler equation of motion to **derive** the Bernoulli equation to **analyze** complex fluid flow problems using principles of mathematics and engineering sciences.	3

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

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

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**DETERMINATION OF COEFFICIENT OF DISCHARGE OF VENTURI METER**
	Calibration of Venturimeter.
WEEK II	**DETERMINATION OF COEFFICIENT OF DISCHARGE OF ORIFICE METER**
	Calibration of Orifice meter.
WEEK III	**DETERMINATION OF FRICTION FACTOR**
	Determination of friction factor for a given pipe line.
WEEK IV	**VERIFICATION OF BERNOULLI'S THEOREM**
	Verification of Bernoulli's theorem.
WEEK V	**PERFORMANCE TEST ON PELTON WHEEL TURBINE**
	Performance test on impulse turbine.
WEEK VI	**PERFORMANCE TEST ON FRANCIS TURBINE**
	Performance test on mixed flow reaction turbine.
WEEK VII	**PERFORMANCE TEST ON KAPLAN TURBINE**
	Performance test on axial flow reaction turbine.
WEEK VIII	**PERFORMANCE TEST ON RECIPROCATING PUMP**
	Performance test on positive displacement pump.
WEEK IX	**PERFORMANCE TEST ON CENTRIFUGAL PUMP**
	Performance test on rotodynamic pumps.
WEEK X	**IMPACT OF JET ON VANES**
	Determination of coefficient of impact for stationary and fixed vanes.
WEEK XI	**PERFORMANCE TEST ON MULTI STAGE CENTRIFUGAL PUMP**
	Performance test on centrifugal pumps in series.
WEEK XII	**LOSS OF HEAD DUE TO SUDDEN CONTRACTION**
	Determination of energy losses due to sudden contraction of pipes.

TEXTBOOKS

1. H Modi, Seth, Hydraulics, Fluid Mechanics and Hydraulic Machinery, Rajsons, Publications, 21st Edition, 2017.
2. D.S. Kumar,"Fluid Mechanics and Fluid Power Engineering", Kotaria & Sons, Reprint, 2013.

REFERENCE BOOKS:

1. Dr. R K Bansal, A Text Book of Fluid Mechanics and Hydraulic Machines, Laxmi Publications, 9th Edition, 2015.
2. D. Rama Durgaiah, "Fluid Mechanics and Machinery", New Age International, 1st Edition, 2002.

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	Determination of coefficient of discharge of Venturi meter.	CO 1, CO 2	T1:7.10
2	Determination of coefficient of discharge of Orifice meter.	CO 1, CO 2	T1:11.5
3	Determination of friction factor and coefficient of friction for a given pipe line.	CO 3	T1:7.7
4	Verification of Bernoulli's theorem	CO 4	T1:21.12
5	Performance test on Pelton wheel turbine	CO 5, CO 6	T1:21.5
6	To Performance test on Francis turbine	CO 4, CO 6	T1:23.2
7	Performance test on Kaplan turbine.	CO 4, CO 6	R1:24.3
8	Performance test on Reciprocating pump	CO 6	R2:2.6
9	Performance test on Centrifugal pump.	CO 6	R1:3.18
10	Impact of jet on vanes.	CO 5, CO 6	T2:3.18
11	Performance test on multi stage Centrifugal pump	CO 6	R2:7.12
12	Loss of head due to sudden contraction in a pipe.	CO 6	T2:3.18

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Reynold's Number:** Determination of Reynold numbers for laminar, transion and turbulent flows.
2	**Thoma's Cavitation Factor:** Determine Thoma's cavitation factor for diffent cross-sections of a draft tube.
3	**Constant Speed Characteristic Curves:** Operate the turbines at constant speed and compare the performance with constant head.
4	**Minor Energy Losses:** Determine the minor energy losses for sudden enlargement and an obstruction in a pipe.

Signature of Course Coordinator **HOD, ME**
Mr. A Somaiah, Assistant Professor

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

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**APPLIED THERMODYNAMICS LABORATORY**				
Course Code	AMEC17				
Program	B.Tech				
Semester	IV	ME			
Course Type	CORE				
Regulation	IARE - UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Mr. G Aravind Reddy, Assistant Professor				

I COURSE OVERVIEW:

The I.C. Engine laboratory is intended to study the working principle of IC engines (both SI and CI engines), performance and characteristics in terms of heat balancing, economical speed variations, air fuel ratio influence on the engine to reinforce classroom theory by having the student perform required tests, analyze subsequent data, and present the results in a professionally prepared report.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Applied Thermodynamics 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 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 labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

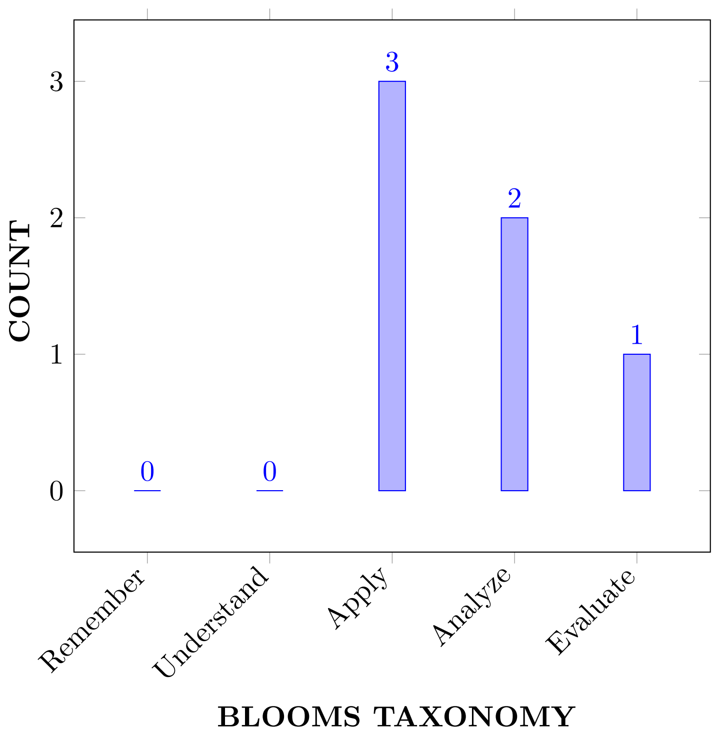
I	The obtain cycle timings of S.I and C.I engines and visualize the working of the models
II	The operating principle of C.I and S.I engines and to determine performance characteristics of engines.
III	The Performance test for 4-stroke SI engine and draw performance curves and Determine the volumetric efficiency and break thermal efficiency..

VII COURSE OUTCOMES:

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

CO 1	**Understand** the various components and mechanisms of I. C. Engines to Appreciate the Mechanism of ports /Valves functioning in 2-stroke petrol /Diesel engine	Apply
CO 2	**Evaluate** the performance characteristics of single cylinder petrol engine at different loads and single cylinder diesel engine at different loads and draw the heat balance sheet	Evaluate
CO 3	**Analyze** the method of finding the indicated power ofindividual cylinders of an engine by using morse test	Apply
CO 4	**Distinguish** the performance characteristics of Multi cylinder engine for various operating conditions.	Analyze
CO 5	**Apply** the concepts of intercooling in multistage air compressor for minimum power input.	Apply
CO 6	**Determine** the performance parameters of internal combustion engines under variable input conditions for optimum fuel consumption.	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises/CIA/SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	Lab Exercises/CIA/SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises/CIA/SEE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 2	Formulate and evaluate concepts of thermo-fluid systems to provide solutions for inter disciplinary engineering applications sustainable designs for new generation automotive systems.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Utilize the concept of calibration to a considerable extent appreciate (understanding) their importance and applicability (apply) in solving (complex) fluid flow engineering problems by applying the **principles of Mathematics and Engineering**	3
	PO 2	Understand the (given **problem statement**) calibration procedure for (provided **information and data**) in reaching substantiated conclusions by the interpretation of results	3
	PSO 2	Apply (**knowledge**) properties, various types and patterns of fluid flow configurations (apply) for solving design problems by applying the **principles of Mathematics, Science and Engineering**	2

CO 2	PO 1	Explain (understanding) various effects of viscosity in flow through pipes and apply Newtons law of viscosity, in calculating energy loss by applying **principles of Mathematics, Science and Engineering**	3
	PO 5	Understand the (given **problem statement**) effects of viscosity, and calorific value of the fuels. (from the provided **information**) in solving analysis problems.	2
	PSO 2	Apply (**knowledge**) Newtons law of viscosity (understanding) in body, under different inlet conditions in (apply) solving flow through pipes by applying the principles of **Mathematics, Science and Engineering**	2
CO 3	PO 1	Summarize (**knowledge**) performance characteristics of single cylinder petrol engine at different loads and single cylinder diesel engine at different loads and draw the heat balance sheet textbfprinciples of Mathematics, Science and Engineering	3
	PO 3	Understand the given **problem statement** and formulate (complex)and method of finding the indicated power of individual cylinders of an engine by using morse test **interpretation** of variations in the **results**.	3
	PSO 2	Apply (knowledge) the concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications. **principles of Mathematics, Science and Engineering**	2
CO 4	PO 1	Recognize (knowledge) the importance and application (apply) of dimensions, units and dimensional homogeneity in solving (complex) engineering problems with specific emphasis to fluid mechanics by applying the **principles of Mathematics, Science and Engineering**	3
	PO 5	Understand the given **problem statement and formulate** the dimensional analysis and similarity parameters for predicting physical parameters that govern fluid systems in designing prototypes devices	2
	PSO 2	Apply (knowledge) concept of Awareness of components of given IC engine and assembling /disassembling of parts. designing prototypes devices (apply) solving design problems by applying the **principles of Mathematics, Science and Engineering**	2
CO 5	PO 1	Apply the basic conservation laws of science for various phenomena of fluid systems and use **mathematical principles** for deriving (complex) fluid flow engineering equations by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals** of fluid mechanics.	3
	PO 3	Apply (**knowledge**) properties, various types and patterns of fluid flow configurations (apply) for solving design problems by applying the **principles of Mathematics, Science and Engineering**	2

	PO 5	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of Automotive sector.	2
	PSO 2	Apply (knowledge) the concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications. **principles of Mathematics, Science and Engineering**	2
CO 6	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** principles to understand the thermodynamic laws and its applications	2
	PO 3	Apply (knowledge) the concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications. **principles of Mathematics, Science and Engineering**	3

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

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

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**IC Engine Valve/Port Timing Diagram**
	Drawing valve and port timing diagram for 4-stroke diesel and 2-stroke petrol engine respectively.
WEEK II	**IC Engine performance test for 4-stroke SI Engine**
	Performance test for 4-stroke SI engine and draw performance curves
WEEK III	**IC Engine performance test for 2-stroke SI Engine**
	Determination of volumetric efficiency and break thermal efficiency
WEEK IV	**IC Engines Morse, retardation and motoring test**
	Determination of frictional power of IC engine.
WEEK V	**IC Engines heat balance-CI/SI engines**
	Balancing of heat losses and heat input in SI/CI engines
WEEK VI	**IC Engines economical speed test on SI Engine**
	Performance Test on SI engine with speed as a parameter
WEEK VII	**IC Engines effect of Air/Fuel ration in a SI engine**
	Calculating air/fuel ratio of a 4-stroke SI Engine.
WEEK VIII	**Performance test on Variable Compression Ratio(VCR) engine**
	Performance Test on CI engine when the compression ratio is changing.
WEEK IX	**IC Engine performance test on 4-Stroke CI engine**
	Performance Test on 4-stroke CI engine and to draw the performance curves
WEEK X	**Volumetric Efficiency of Reciprocating Air compressor unit**
	Performance of air compressor unit
WEEK XI	**Disassembly/Assembly of Engines**
	Awareness of components of given IC engine and assembling /disassembling of parts
WEEK XII	**Study of Boilers**
	To study the working operation of different types of boilers

TEXTBOOKS

1. V. Ganesan, —I.C. Engines, Tata McGraw-Hill, 3rd Edition, New Delhi, India. 2011.
2. B. John Heywood, —Internal combustion engine fundamentals, Tata McGraw-Hill, 2nd Edition, New Delhi. 2011

REFERENCE BOOKS:

1. R. K. Rajput , —Thermal Engineering, Lakshmi Publications, 18th Edition, 2011

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	Determination of cUnderstand the concept of Drawing valve and port timing diagram for 4-stroke diesel and 2-stroke petrol engine respectively.	CO 1, CO 2	T1:7.10
2	Know the Performance test for 4-stroke SI engine and draw performance curves	CO 1, CO 2	T1:11.5
3	Understand Basic fundamentals and Determination of volumetric efficiency and break thermal efficiency	CO 3	T1:7.7
4	Understand fundamentals and Determination of frictional power of IC engine.	CO 4, CO 5	T1:21.12
5	Performance of Machining practice on Balancing of heat losses and heat input in SI/CI engines	CO 5, CO 6	T1:21.5
6	Performance Test on SI engine with speed as a parameter.	CO 4, CO 6	T1:23.2
7	Calculating air/fuel ratio of a 4- stroke SI Engine.	CO 4, CO 6	T1:24.3
8	Understand the Performance Test on CI engine when the compression ratio is changing.	CO 6	R1:2.6
9	Performance Test on 4-stroke CI-engine and to draw the performance curves	CO 5, CO 6	T2:3.18
10	Understand the Performance of air compressor unit.	CO 5, CO 6	T2:3.18
11	Awareness of components of given IC engine and assembling/disassembling of parts.	CO 5, CO 6	R1:7.12
12	To study the working operation of different types of boilers	CO 6	T2:3.18

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**2-Stroke Petrol Engine:** Demonstration the working of 2-Stroke Petrol Engine and calculation of the efficiency and maintaing the economy of the engine .
2	**Heat balance sheet:** Demonstration of all the efficiency and Calculating air/fuel ratio of a 4-stroke SI Engine at different angle of strokes and calculation of heat balance sheet accordingly.
3	**Multi cylinder:** Execute the process to extract the different data from the test rig at various conditions

Signature of Course Coordinator **HOD, ME**

Mr. G Aravind Reddy, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**MANUFACTURING PROCESS LABORATORY**				
Course Code	AMEC15				
Program	B.Tech				
Semester	IV	ME			
Course Type	CORE				
Regulation	IARE - UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1
Course Coordinator	Mr.G.Praveen Kumar, Assistant Professor				

I COURSE OVERVIEW:

This course is to introduce the concept of manufacturing process with the help of various processes widely employed in the industries. This course consists of casting, welding, sheet metal forming, extrusion and forging processes with the related details of equipment and applications. It Introduces the different manufacturing processes and breakeven analysis. Engineering materials, laying emphasis on ferrous and non-ferrous materials along with the heat treatment of metals discusses the special casting processes and metal-forming processes respectively.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC02	II	Manufacturing Pracice

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Manufacturing Process Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

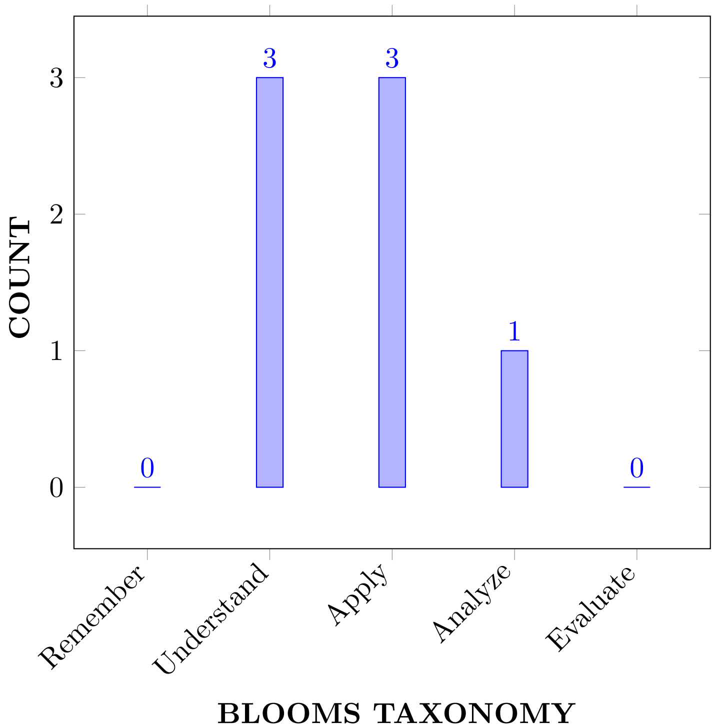
I	The Importance manufacturing sciences in the day-to-day life, and study the basic manufacturing processes and tools used.
II	The knowledge in thermal, metallurgical aspects during casting and welding for defect free manufacturing components..
III	The design features that make each of this manufacturing process both harder, easier, assess design and manufacturing features on real products.

VII COURSE OUTCOMES:

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

CO 1	**Identify** the design steps involved in making a castings for automotive components. .	Apply
CO 2	**Demonstrate** practical usage of Gas welding and Arc welding Techniques for making Lap and Butt joints.	Understand
CO 3	**Make use of** different types of welding techniqies for Industrial Applications.	Apply
CO 4	**Analyze** various defects during gas welding,arc welding process and their causes and remedies.	Analyze
CO 5	**Demonstrate** working principle of various sheet metal forming process such as Hydraulic press, deep drawing and bending operation. .	Understand
CO 6	**Demonstrate** the various process in making of plastic components for engineering / domestic applications.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Selection of operations which have to be carried out casting process for a specific application, need the **knowledge of science and engineering fundamentals**	3
	PSO 3	Make use of **computational and experimental tools** to real time practical problems in manufacturing process	2
CO 2	PO 1	Identify (knowledge) in suitable techniquies involved in design,welding to achieve error free components using in solving (complex) engineering problems by applying the **principles of Mathematics, Science and Engineering fundamentals**	3
	PO 2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to manufacturing process.	2

CO 3	PO 1	Apply the operational principles of different welding equipments for quality welding by applying the **knowledge of mathematics, science and engineering fundamentals**	3
	PO 2	Understand the given **problem statement and apply data validation techniques to resolve specific engineering problems** related to wedling strength by identification of process adoption for the specially develop component	2
CO 4	PO 1	Identify the causes and remedies of welding defects using **Scientific Principles of Methodology and engineering fundamentals**	3
CO 5	PO 2	Make use of the metal forming techniques used in Design, **Model Creation and Validation** of component Parts by Problem Analysis.	2
	PO 3	Understand the given problem statement related to their working principle and based upon type of manufacturing process.	2
	PSO 3	Identify the **scientific principle** involved in rolling processby **Qualitative and Quantitative methods** to their engineering problems.	2
CO 6	PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2

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

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

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**PATTERN MAKING**
	Pattern design and making.
WEEK II	**SAND CASTING**
	Moulding, melting and casting
WEEK III	**METAL CASTING**
	Moulding, melting and casting .
WEEK IV	**ARC WELDING**
	ARC welding lap and butt joint
WEEK V	**SPOT WELDING**
	Spot welding lap and butt joint.
WEEK VI	**GAS WELDING**
	Gas Welding lap and butt joint.
WEEK VII	**BRAZING**
	Brazing lap and butt joint.
WEEK VIII	**APPLICATION OF SIMPLE DIE**
	Blanking and piercing.
WEEK IX	**APPLICATION OF COMPOUND DIE**
	Blanking and piercing
WEEK X	**PROCESSING OF PLASTICS**
	Injection moulding
WEEK XI	**PROCESSING OF PLASTICS**
	Blow moulding
WEEK XII	**RIVETING**
	Riveting of a plates
WEEK XIII	**SAND PROPERTIES TESTING**
	Sand properties testing for strengths and permeability

REFERENCE BOOKS:

1. R. K. Jain, “Production Technology”, Khanna Publishers, 18th Edition,2013.
2. T. V. Ramana Rao, “Metal Casting”, New Age, 1st Edition, 2010.
3. Philips Rosenthal, “Principles of Metal Castings”, TMH, 2nd Edition, 2001
4. B. S.Raghuwamshi, “A Course in Workshop Technology”, Dhanpat Rai and Sons, 2014.
5. Kalpakjin S, “Manufacturing Engineering and Technology”, Pearson Education, 7th Edition,2014
6. HMT, “Production Technology”, McGraw-Hill Education, 1st Edition, 2013.

XV COURSE PLAN:

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

S.No	Topics to be covered	CO’s	Reference
1	Pattern design and making, casting drawing.	CO 1	R1: 1.2
2	Sand properties testing for strengths and permeability.	CO 2	R2: 3.5
3	Moulding, melting and casting	CO 3	R1: 3.4
4	Arc welding lap and butt joint	CO 3	R1: 2.2
5	Spot welding, TIG welding.	CO 4	R1: 2.4
6	brazing	CO 4	R3: 4.5
7	Blanking and piercing operations	CO 5	R3: 4.6
8	study of simple, compound and progressive press tool.	CO 5	R3: 4.6
9	Hydraulic press: deep drawing and extrusion operation.	CO 5	R2: 5.1
10	Bending and other operation	CO 6	R2: 5.2
11	Injection moulding.	CO 6	R1: 7.1
12	Blow moulding.	CO 6	R1:7.2
13	Riveting of a plates	CO 6	R1:7.3

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Design and develop:** Design and develop Gating system for cating process.
2	**Optimization:** welding Process parameters for optimal weld strength using a Design of Experiments approach.
3	**Design and develop:** Design and Development of Welded joints
4	**Design and develop:** Design and develop of Hydraulic press, deep drawing and bending dies
5	**Design and develop :** Design and develop Injection and blow moulding dies

Signature of Course Coordinator **HOD,ME**
Mr.G.Praveen Kumar, Assistant Professor

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

COURSE DESCRIPTION

Department	**Mechanical Engineering**				
Course Title	**Dynamics of Machinery**				
Course Code	AMEC18				
Program	B.Tech.				
Semester	V				
Course Type	Core				
Regulation	UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Dr. V V S H Prasad, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC01	II	Engineering Mechanics

II COURSE OVERVIEW:

This course focuses on mechanical devices that are designed to have mobility to perform certain functions. In this process they are subjected to some forces. The study of Dynamics of machinery leads us to design machines by understanding the relationship between the movement of various parts of machine and the different forces that are acting on them. This course will provide the knowledge on how to analyze the motions of mechanisms and design mechanisms to give required strength. This includes relative static and dynamic force analysis and consideration of gyroscopic effects on aero planes, ships, automobiles like two wheelers and four wheelers.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Dynamics of Machinery	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
25 %	Understand
50 %	Apply
25 %	Analyze
0 %	Evaluate
0 %	Create

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

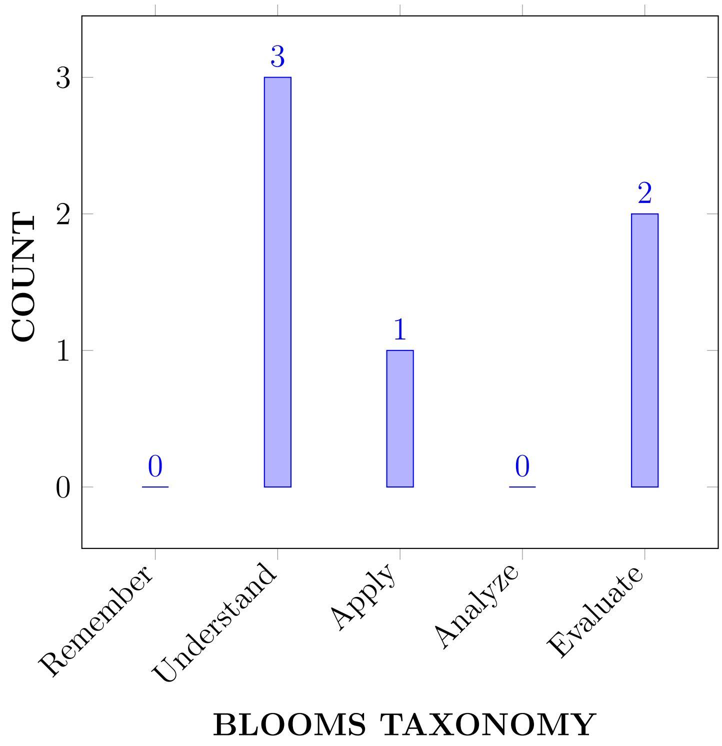
I	The concepts of precision, static and dynamic forces of planer mechanisms by neglecting friction of aero planes, sea vessels, auto mobiles and various force members.
II	The knowledge of engineering mechanics for identifying the coefficient of friction and engine speed of the various contact bodies (Clutches and Brakes) and speed controlled devices, variations of torques and fluctuation of speeds of IC engines.
III	The magnitude and direction of balanced mass for unbalanced rotary and reciprocating engines with the fundamentals of applied physics.
IV	Mathematical modeling of various degree of freedom systems to interpret the various vibration parameters.

VII COURSE OUTCOMES:

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

CO 1	**Discuss** the Gyroscopes, effect of precession motion on the stability of moving vehicles such as motor car, motor cycle, aero-planes and ships.	Understand
CO 2	**Determine** the angle of heel to avoid upside down of a two wheeler vehicle while taking in left and right turns.	Evaluate
CO 3	**Illustrate** the static and dynamic force analysis of two and three force members by graphical super position method.	Understand
CO 4	**Apply** the laws of friction on clutches, brakes and dynamometers to reduce the power losses for the effective torque transmission.	Apply
CO 5	**Justify** the importance of torque and fluctuation of speeds for single and multi cylindered engines and governors to increase the mechanical efficiency.	Evaluate
CO 6	**Determine** the balanced mass and natural frequency for unbalanced rotary and reciprocating engines by analytical and graphical methods and equations of motion	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	2	CIE/Quiz/AAT
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	2	CIE/Quiz/AAT
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	CIE/Quiz/AAT
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2	CIE/Quiz/AAT
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	3	Quiz
PSO 3	Focus on ideation and research towards product development using additive manufacturing, CNC simulation and high speed machining.	2	Quiz

3 = High; 2 = Medium; 1 = Low

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

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** to find the gyroscopic effect	3
	PO 2	**Identify the problem statement dentify the problem statement, formulation , data collection ,validation and interpretation** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	5
	PO 10	**Identify the problem statement** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	2
CO 2	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** and determine the coefficient of friction of various clutches at different conditions	3
	PO 2	Illustrate the performance parameters of four bar mechanisms **first principles of Mathematics and engineering sciences and identify the problem statement, formulation , data collection ,validation and interpretation.**	5
	PO 5	**Identify the problem statement** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to clutches	1
CO 3	PO 1	Identify the speed of governors **using principles of mathematics, science, and engineering fundamentals.**	3
	PO 7	**Identify the problem statement, socio economic and environmental** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to governors	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 4	PO 1	Justify the knowledge of different forces (**scientific Principles and mathematical principles**) for governors and describe different performance parameters.	3
	PO 2	Determine the condition for correct steering **and also identify the problem statement, formulation , data collection ,validation and interpretation** of various steering mechanisms	5
	PO 3	**Identify the customer needs, investigate, innovate** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to engines	5
CO 5	PO 1	Develop the fundamentals of engineering and science in identifying the unbalanced mass **using the fundamentals of engineering and mathematical equations**	3
	PO 8	**Identify the problem statement and apply ethics to** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to unbalanced masses	2
	PO 11	**Identify the problem statement for quality, budget, schedule** (mission requirement), to select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to unbalanced machines	6
	PS O1	**Identify the problem statement** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	1
CO 6	PO 1	Formulate the problem statement and model the system for getting the solution of cams to regulate the speed of machines**using fundamentals of science &and engineering fundamentals.**	3
	PO 4	Understand the technical concepts of vibration and interpret the equilibrium conditions for various applications for **complex engineering problems.**	5
	PO 12	Investigate and define a problem and identify constraints of mechanisms **environmental and sustainability limitations, health and safety and risk assessment issues** when dealing with performance of followers and their application on real world problems	4

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 3	**Identify the problem statement** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	2

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\ \% < C < 60\%$ –Moderate

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

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

x	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**PRECESION, STATIC AND DYNAMIC FORCE ANALYSIS OF PLANAR MECHANISMS**
	Precession: Gyroscopes, effect of processional motion on the stability of moving vehicles such as motor car, motor cycle, aero-planes and ships, static and dynamic force analysis of planar mechanisms: Introduction to free body diagrams, conditions of equilibrium, two and three force members, inertia forces and D-Alembert's principle, planar rotation about a fixed centre.
MODULE II	**CLUTCHES, BRAKES AND DYNAMOMETERS**
	Clutches: Friction clutches, Single disc or plate clutch, multiple disc clutches, cone clutch and centrifugal clutch; Brakes and dynamometers: Simple block brakes, internal expanding brake, band brake of vehicle; Dynamometers absorption and transmission types, general description and method of operation.
MODULE III	**TURNING MOMENT AND GOVERNORS**
	Turning moment diagrams and flywheels: turning moment: Inertia torque, angular velocity and acceleration of connecting rod, crank effort and torque diagrams, fluctuation of energy; Design of flywheels. Governors
MODULE IV	**BALANCING OF ROTATORY AND RECIPROCATING MASSES**
	Balancing: Balancing of rotating masses, single and multiple-single and different planes-balancing of reciprocating masses, primary and secondary balancing-analytical and graphical methods; unbalanced forces and couples: Balancing of V-engines, multi cylinder, inline and radial engines for primary, secondary balancing and locomotive balancing.

MODULE V	MECHANICAL VIBRATIONS
	Vibrations: Free vibration of mass attached to a vertical spring, simple problems on forced damped vibration; Vibration isolation and transmissibility, whirling of shafts, critical speeds, torsional vibrations,two and three rotor systems.

TEXTBOOKS

1. Amithab Ghosh, Asok Kumar Malik, "Theory of Mechanisms and machines", East West Press Pvt Ltd, 2001.
2. S.S Ratan, "Theory of Machines", Tata McGraw-Hill, 9th Edition, 2021
3. R. L. Norton, "Kinematics and Dynamics of Machinery", McGraw-Hill, 1st Edition, 2022.
4. P.L. Balleny, "Theory of Machines and Mechanisms", Khanna publishers, 2021.

REFERENCE BOOKS:

1. J. S. Rao, R.V. Dukkipati, "Mechanism and Machine Theory", New Age Publication, 8th Edition, 2021.
2. Uiker, Penock, Shigley, "Theory of Machines and Mechanisms", Oxford University Press, 10th Edition,2021.

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Introduction to outcome based education		
CONTENT DELIVERY (THEORY)			
1	Introduction to Gyroscopes, angular motion, precession.	CO1	T2 17.2
2	Determination of Gyroscopic couple, problems.	CO2	T2 17.1
3	Effect of gyroscopic couple on stability of moving car.	CO2	T2 17.8
4	Effect of gyroscopic couple on stability of moving motorcycle.	CO2	T2 17.6
5	Effect of gyroscopic couple on stability of aero-plane.	CO1	T2 17.3
6	Effect of gyroscopic couple on stability of moving ship.	CO2	T2 17.4
7	Static and dynamic force analysis of planar mechanisms.	CO3	T2 12.1
8	Free body diagrams, problems.	CO3	T2 12.6
9	Friction circle, Boundary friction.	CO3	T2 8.2
10	Introduction to Clutches, types.	CO4	T2 8.9
11	Introduction to Brakes, classification.	CO4	T2 15.1
12	Introduction to dynamometers, types.	CO4	T2 15.8
13	Methods of operation of dynamometers power, Performance test.	CO4	T2 15.9
14	Calculation of brake torque, problems.	CO5	T2 15.13
15	Turning moment diagrams explanation.	CO5	T2 13.12
16	Inertia torque calculation for connecting rod.	CO5	T2 13.11
17	Problems on inertia torque calculation for connecting rod.	CO5	T2 13.7
18	Fluctuation of energy.	CO5	T2 13.13

19	Flywheel and its function.	CO5	R3 16.12
20	Flywheel design	CO5	R3 16.18
21	Problems on flywheel	CO5	R3 16.21
22	Introduction to governors and their classification	CO6	T2:16.1
23	Watt governor and Porter governor	CO6	T2 16.3,4
24	Proell governor, Hartnell and Hartung governors	CO6	T2:16.5,6
25	Problems on governors	CO6	T2:16.14
26	sensitiveness, isochronisms and hunting, effort and power of governors	CO6	R318.12
27	Balancing of rotating masses	CO6	T2:21.2
28	Problems on balancing of rotating masses.	CO5	T2:21.1
29	Primary balancing of reciprocating masses.	CO5	T2:22.1
30	Secondary balancing of reciprocating masses.	CO5	T2:22.2
31	Higher balancing of reciprocating masses.	CO5	R3 22.10
32	Locomotive balancing.	CO5	R322.4
33	Graphical method of calculating forces and couples.	CO5	R3 22.3
34	Balancing of Multi cylinder and V- Engines.	CO5	R3 22.13
35	Balancing of radial engines.	CO5	R3 22.12
36	Introduction to vibrations and their classification.	CO6	T2.18.1
37	Free vibrations of mass attached to vertical springs.	CO6	T2 18.6
38	Transverse vibrations-Problems.	CO6	R3 23.9
39	Frequency of transverse vibration for concentrated and distributed loads	CO6	R3 23.11
40	Dunkerley's method for calculating frequency.	CO6	R3 23.4
41	Raleigh's method for frequency calculations.	CO6	R3 23.5
42	Critical speeds, Whirling of shafts, problems.	CO6	R3 23.12
43	Torsional vibrations- one rotor system.	CO6	R3 24.4
44	Torsional vibrations- two rotor system.	CO6	R3 24.5
45	Torsional vibrations- three rotor system.	CO6	R3 24.6
PROBLEM SOLVING/ CASE STUDIES			
46	Problems on Gyroscope.	CO6	R3 24.4
47	Problems on gyroscope of two wheeler	CO6	R3 23.18
48	Problems on gyroscope of four wheeler	CO6	R3 23.18
49	Problems on gyroscope of four wheeler with forward rotation of the wheel	CO6	R323.23
50	Problems on clutches	CO6	R3 23.14
51	Balancing of rotating masses	CO5	T2:21.2
52	Problems on balancing of rotating masses.	CO5	T2:21.1
53	Primary balancing of reciprocating masses.	CO5	T2:22.1
54	Secondary balancing of reciprocating masses.	CO5	T2:22.2
55	Higher balancing of reciprocating masses.	CO5	R3 22.10
56	Locomotive balancing.	CO5	R322.4
57	Graphical method of calculating forces and couples.	CO5	R3 22.3
58	Balancing of Multi cylinder and V- Engines.	CO5	R3 22.13

59	Balancing of radial engines.	CO5	R3 22.12
DISCUSSION OF DEFINITION AND TERMINOLOGY			
60	Precissional motion	CO5	T2 13.12
63	Clutches and Brakes	CO5	T2 13.11
64	Unbalancing	CO5	T2 13.7
65	Governors	CO5	T2 13.13
66	Vibrations	CO5	R3 16.12
DISCUSSION OF QUESTION BANK			
1	Module I: Precissional motion	CO 1	R4:2.1
2	Module II: Clutches and Brakes	CO 2	T4:7.3
3	Module III: Unbalancing of rotary and reciprocatory motion of masses	CO 3	R4:5.1
4	Module IV: Governors	CO 4	T1:7.5
5	Module V: Vibrations of damoed, undamped and critical damped structures	CO 5,6	T1: 4.1

Signature of Course Coordinator **HOD, ME**
Dr. V V S H Prasad, Professor

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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**MACHINE TOOLS AND METROLOGY**				
Course Code	AMEC19				
Program	B.Tech				
Semester	V				
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr K. Ch Apparao, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC11	III	Manufacturing Processes

II COURSE OVERVIEW:

Manufacturing Technology is an instructional program that prepares individuals to shape metal parts on machine tools such as lathes, grinders, drill presses, milling machines and shapers. This course includes instruction in safety, making computations related to work dimensions testing feeds and speeds of machines using precision measuring instruments. Metrology is highly valuable for the students and practitioners, specifically from mechanical and allied engineering stream. This course is designed to impart the knowledge about the various machining processes like turning, shaping, planning, drilling, milling and grinding and to develop measurement procedures, conduct metrological experiments.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Manufacturing Technoloy	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

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

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

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

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

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

is given in table

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

VI COURSE OBJECTIVES:

The students will try to learn:

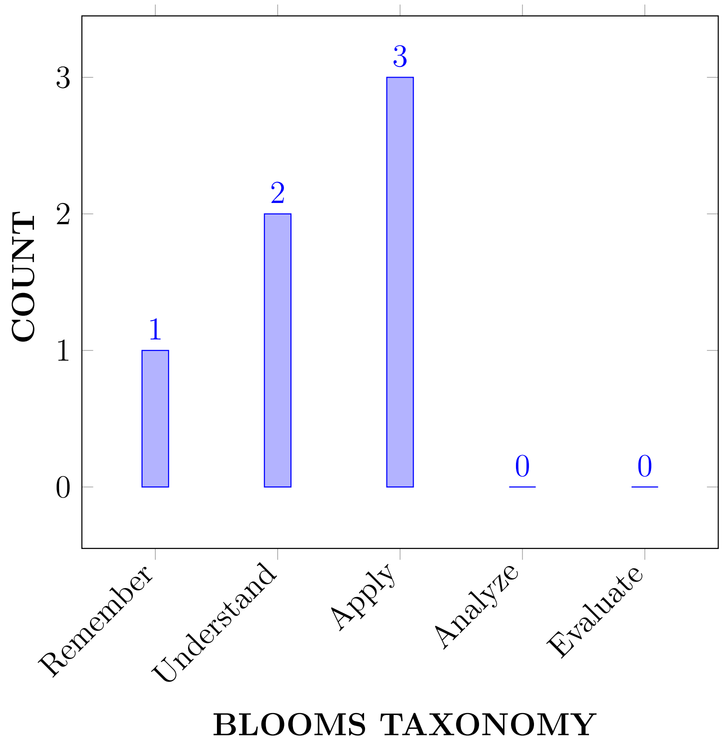
I	The fundamental concepts of the metal cutting principles to study the behavior of various machining processes.
II	The importance of tool materials, cutting parameters, cutting fluids and tool wear mechanisms for optimized machining.
III	The principles of linear and angular measuring instruments for accurate measurement of a given component
IV	The mechanics of machining process and optimization of various significant parameters in order to yield the optimum machining.

VII COURSE OUTCOMES:

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

CO 1	**Recall** the importance of geometry of cutting tools, coolants and tool materials for the analysis of material behavior during manufacturing processes.	Remember
CO 2	**Explain** the operational principles of different lathe machines and various reciprocating machines for quality machining.	Understand
CO 3	**Explain** the working principles of Milling, drilling and surface grinding machines for manufacturing the components of their requirement.	Understand
CO 4	**Apply** the principles of limits, fits and tolerance while designing and manufacturing the components of their requirement.	Apply
CO 5	**Choose** an appropriate measuring instrument for accurate inspection of the dimensional and geometric features of a given component.	Apply
CO 6	**Apply** the various methods for the measurements of screw threads, surface roughness parameters and the working of optical measuring instruments.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIA/Quiz/ AAT/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIA/Quiz/ AAT/SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	CIA/Quiz/ AAT/SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations.	1	CIA/Quiz/ AAT/SEE
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	CIA/Quiz/ AAT/SEE

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	1	CIA/Quiz/ AAT/SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	CIA/Quiz/ AAT/SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing	3	AAT

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recognize (knowledge) the importance of geometry of cutting tool, Tool life, coolants and tool materials to analyze material behaviour during manufacturing processes by applying the principles of **mathematics, science and Manufacturing fundamentals.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO 1	Apply the operational principles of different lathe machines and various reciprocating machines for quality machining by applying the **the knowledge of mathematics, science and engineering fundamentals**	3
CO 3	PO 1	Explain (Understand) the working principles of Milling, drilling and surface grinding machines for solving (complex) manufacturing problems by applying the principles of **mathematics, science and engineering fundamentals**	3
	PO 2	Understand the given **problem statement and formulate** formulate the design (complex) engineering problems for working processes of machine tools from the provided **information and data** in reaching substantiated conclusions by the **interpretation of results.**	4
	PSO 1	**Analysing** the metal cutting process in various machine tools to anable them to design, analyse and fabricate **complex designs.**	2
CO 4	PO 1	Identify (knowledge) the principles of limits, fits and tolerance while designing to get accurate and precision measurement of the manufactured components by using acquired knowledge in **mathematics and science** (physics and engineering).	2
	PO 2	Application of the principles of limits, fits and tolerance while designing can be used for **identifying, formulating, and analysing complex problems.**	3
	PSO 1	Ability to **apply** the principle of limits, fits and tolerance while designing and manufacturing help them to design, analyse and fabricate **complex designs.**	2
CO 5	PO 1	Ability to select, calibrate and use appropriate measuring equipment requires identification of measurend, selection of equipment by referring standard available equipment, and analysing the results using reference values are carried out by applying the **knowledge of mathematics, science and metrology engineering fundamentals**	3
	PO 3	A good **knowledge** in **measuring equipment.**and an ability to calibrate, equip them to **design solutions to complex engineering Problems** by measuring various parameters which are affecting them.	3
	PSO 1	Ability to **apply** the principle of limits, fits and tolerance while designing and manufacturing help them to design, analyse and fabricate **complex designs.**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	PO 1	Ability to select and use various methods for the measurements of screw threads, surface roughness parameters and the working of optical measuring instruments for proper analysis of results to reach actual conclusion requires some research based **knowledge of mathematics, science and metrology engineering fundamentals.**	3
	PSO 1	Ability to **apply** the principle of limits, fits and tolerance while designing and manufacturing help them to design, analyse and fabricate **complex designs.**	2

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	3	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	3	3	3	-	-	-	-	3	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-
TOTAL	18	6	3	-	3	3	3	-	-	-	-	3	5	-	-
AVERAGE	3	2	3	-	3	3	3	-	-	-	-	3	2.5	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

X	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**BASIC MECHANISM OF METAL CUTTING**
	Elementary treatment of metal cutting theory,element of cutting process, geometry of single point tool and angles chip formation and types of chips,built up edge and its effects, chip breakers: Mechanics of orthogonal cutting, Merchant'sforcediagram, cutting forces, cutting speeds, feed, depth of cut,tool life, coolants, machinability, tool materials.
MODULE II	**MACHINE TOOL - I**
	Engine lathe, Principle, specification, types, work and tool holding devices, Automatic lathes, classification: Single spindle and multi-spindle automatic lathes and its tool layouts; Shaping, slotting and planning machines, Principles of working, specification, operations performed, Kinematic scheme.
MODULE III	**MACHINE TOOL - II**
	Milling machine, classifications, specifications, working principles of milling machines; Geometry of milling cutters, methods of indexing, kinematic scheme of milling machines. Drilling and boring machines, principles of working, specifications, types, operations performed, twist drill; Kinematics scheme of the drilling and boring machines.

MODULE IV	GEOMETRICAL DIMENSIONING AND TOLERANCES
	Systems of Limits and Fits: Introduction, normal size, tolerance limits, deviations, allowance, fits and their types, unilateral and bilateral tolerance system, hole and shaft basis systems, Interchangeability and selective assembly; Linear Measurement: Slip gauges, dial indicator, micrometers; Measurement of angles and tapers: Bevel protractor, angle slip gauges, spirit levels, sine bar.
MODULE V	MEASURING INSTRUMENTS
	Optical measuring instruments: Tool maker's microscope and its uses, collimators, optical projector, interferometer; Screw thread measurement: Element of measurement, errors in screw threads, measurement of effective diameter, angle of thread and thread pitch, profile thread gauges; Surface roughness measurement: Numerical assessment of surface finish: CLA, R.M.S Values, Rz values, methods of measurement of surface finish: profilograph, talysurf - ISI symbol for indication of surface finish.

TEXTBOOKS

1. Dr. R. Kesavan, Dr. R. Kesavan, "Machine Tools" Laxmi publications, 2nd Edition, 2016.
2. N. K Mehta, "Metal Cutting and Design of Cutting Tools, Jigs and Fixtures", McGrawHill Education, 1st Edition,2014.
3. T. L. Chaudhary, "Metal Cutting and Mechanical Tool Engineering", Khanna Publishers, 5th Edition, 2013.
4. R. K. Jain, Engineering Metrology, Khanna Publishers, 1st Edition, 2013.4. R. K. Jain, Engineering Metrology, Khanna Publishers, 1st Edition, 2013.

REFERENCE BOOKS:

1. Yuan S W, "Foundations of fluid Mechanics", Prentice-Hall, 2nd Edition, 1987.

WEB REFERENCES:

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

COURSE WEB PAGE:

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
	OBE DISCUSSION		
1	Discussion on OBE to equip the learning skills of students		
	CONTENT DELIVERY (THEORY)		
2	Introduction of Manufacturing and Machine tools	CO 1	T2: 1.1-1.5, T1: 4.1
3	Types of metal cutting processes and nomenclature of single point cutting tool	CO 1	T2: 1.1-1.5, T1: 4.1

4	Mechanism of chip formation in machining	CO 1	T2: 1.1-1.5, T1: 4.1
5	Mechanics of orthogonal cutting	CO 1	T2: 1.1-1.5, T1: 4.1
6	Merchant theory- Orthogonal Cutting forces	CO 1	T2: 1.1-1.5, T1: 4.1
7	Sources and causes of Heat generation in machining process	CO 1	T2: 1.1-1.5, T1: 4.1
8	Classification of cutting tools and tool materials	CO 1	T2: 1.1-1.5, T1: 4.1
9	Tool life based on Taylors equation	CO 1	T2: 1.1-1.5, T1: 4.1
10	Cutting fluids and Machinability	CO 1	T2: 1.1-1.5, T1: 4.1
11	Introduction of Lathe and uses of their parts	CO 2	T2: 1.1-1.5, T1: 4.1
12	Types of Lathes and work holding devices	CO 2	T2: 1.1-1.5, T1: 4.1
13	Lathe operations	CO 2	T2: 1.1-1.5, T1: 4.1
14	Semi-automatic and Automatic Lathes	CO 2	T2: 1.1-1.5, T1: 4.1
15	Introduction of reciprocating machines – Shaping machine	CO 3	T2: 1.1-1.5, T1: 4.1
16	Classifications of Shaping machines	CO 3	T2: 1.1-1.5, T1: 4.1
17	Reciprocating Mechanisms	CO 3	T2: 1.1-1.5, T1: 4.1
18	Introduction of Planning machine and uses of their parts	CO 3	T2: 1.1-1.5, T1: 4.1
19	Classifications of planning machines	CO 3	T2: 1.1-1.5, T1: 4.1

20	Introduction of slotting machine and uses of their parts	CO 3	T2: 1.1-1.5, T1: 4.1
21	Introduction of milling machine and its working principle	CO 4	T2: 1.1-1.5, T1: 4.1
22	Classifications of Milling machines	CO 4	T2: 1.1-1.5, T1: 4.1
23	Milling operations	CO 4	T2: 1.1-1.5, T1: 4.1
24	Work holding devices of milling machines	CO 4	T2: 1.1-1.5, T1: 4.1
25	Nomenclature of milling cutters and their types	CO 4	T2: 1.1-1.5, T1: 4.1
26	Introduction of drilling machines and their types	CO 4	T2: 1.1-1.5, T1: 4.1
27	Drilling operations	CO 4	T2: 1.1-1.5, T1: 4.1
28	Nomenclature of drill bits and their types	CO 4	T2: 1.1-1.5, T1: 4.1
29	Introduction of drilling machines and their types	CO 4	T2: 1.1-1.5, T1: 4.1
30	Introduction of Limit, Fits and Tolerances	CO 5	T2: 1.1-1.5, T1: 4.1
31	Terminology for fits and tolerances	CO 5	T2: 1.1-1.5, T1: 4.1
32	Types of Fits – Hole/shaft base systems	CO 5	T2: 1.1-1.5, T1: 4.1
33	Types of Assemblies	CO 5	T2: 1.1-1.5, T1: 4.1
34	Working principles of Linear measuring Instruments – Slip gauges, Micrometers	CO 5	T2: 1.1-1.5, T1: 4.1
35	Working principles of Angular measuring Instruments – bevel protractor, sine bar	CO 5	T2: 1.1-1.5, T1: 4.1

36	Working principles of Dial indicator, angular slip gauges	CO 6	T2: 1.1-1.5, T1: 4.1
37	Working principles of Tool maker's microscope and its uses	CO 6	T2: 1.1-1.5, T1: 4.1
38	Working principles of optical projector, interferometer and their uses	CO 6	T2: 1.1-1.5, T1: 4.1
39	Screw thread measurement: Element of measurement, errors in screw threads	CO 6	T2: 1.1-1.5, T1: 4.1
40	Surface roughness measurement: Numerical assessment of surface finish	CO 6	T2: 1.1-1.5, T1: 4.1
41	Methods of measurement of surface finish	CO 6	T2: 1.1-1.5, T1: 4.1
PROBLEM SOLVING/ CASE STUDIES			
1	The useful tool life of HSS tool machinery mild steel at 18m/min is 3 hrs. calculate the tool life when the tool operates at 24m/min.	CO 1	T2: 1.1-1.5, T1: 4.1
2	In an orthogonal cutting operation on a work piece of width 2.5mm, the uncut chip thickness was 0.25mm and 25 degree. It was observed that the chip thickness was 1.25mm.The cutting force was measured to be 900N and the thrust force was found to be 810 N. (a) Find the shear angle. (b) If the coefficient of friction between the chip and the tool, was 0.5, what is the machining constant Cm	CO 1	T1: 1.1-1.5, T2 : 4.1
3	The Taylor's tool life equation for machining C-40 steel with a 18-4-1 HSS cutting tool at a feed of 0.8 m/min and a depth of cut 4mm. The following V and T observation have been noted. Calculate n, C and also recommended the cutting speed for a desire tool life of 60min V (m/min) 35, 25 and T (min) 80,30.	CO 1	T1: 1.1-1.5, T2 : 4.1
4	Estimate the machine time to turn a MS bar of 50mm diameter down to 65mm for a length of 250mm in a single cut. Assume cutting as 20 m/min and feed as 0.3 mm/rev.	CO 2	T2: 1.1-1.5, T1: 4.1
5	Determine the machining time to turn the dimensions. The material is mild steel, the cutting speed with HSS tool being 100 m/min and feed is 0.9 mm rev.	CO 2	T2: 1.1-1.5, T1: 4.1
6	A CI flange of 200mm OD has a bore of 80 mm. This is to be faced on a lathe. Calculate the machining time to face the part, given the feed 0.9 mm/rev and cutting speed of 70 m/min	CO 2	T2: 1.1-1.5, T1: 4.1

7	A 9 cm thick laminated plate consists of a 7cm thick brass and a 2cm thick mild steel plate. A 20 mm diameter hale is to be drilled through the plate. Estimate the total time taken for drilling if Cutting speed of brass = 44 m/min Cutting speed for mild steel = 30 m/min Feed of 20mm drill for brass = 0.26 mm/rev	CO 3	T2: 1.1-1.5, T1: 4.1
8	Find the time required to drill 5 holes in a CI flange of 40mm depth, if the hole diameter is 30mm. Assume cutting speed as 24.9 m/min and feed as.06 cm/rev.	CO 3	T2: 1.1-1.5, T1: 4.1
9	How long will it take a 12.7 mm to drill a hole 50mm deep is brass. Take cutting speed as 75 m/min and feed as 0.175 mm/rev. Take A=0.8D for through hole.	CO 3	T2: 1.1-1.5, T1: 4.1
10	In an assembly of two parts 50mm nominal diameter the lower deviation of the hole is zero and the higher is 4 microns; while that of shaft is -4 and -8 microns respectively. Estimate the allowance and state the type of fit of the assembly	CO 4	T2: 1.1-1.5, T1: 4.1
11	Between mating parts of 100mm basic size, the actual interference fit is to be from 0.05mm to 0.12mm. tolerance for the hole is the same as the tolerance for the shaft. Find the size of both the shaft and the hole on a) hole basis unilateral system and b) shaft basis unilateral system.	CO 4	T2: 1.1-1.5, T1: 4.1
12	A 200mm sine bar is to be set up to an angle of 25 Degrees. Determine the slip gauges needed from 87 pieces set.	CO 4	T2: 1.1-1.5, T1: 4.1
13	Calculate the CLA(Ra) value of a surface for which the sampling length was 0.8mm. The graph was drawn to a vertical magnification of 10,000 and a horizontal magnification of 100, and the areas above and below the datum line were: Above: 150 80 170 40mm2 Below: 80 60 150 120mm2	CO 5, CO 6	T2: 1.1-1.5, T1: 4.1
14	In the measurement of surface roughness heights of 20 successive peaks and troughs were measured from a datum and were 35, 25, 40, 22, 35, 18, 42, 25, 35, 22, 36, 18, 42, 22, 32, 21, 37, 18, 35, 20 microns. If these measurements were obtained on 20mm length, determine CLA and RMS values of rough surface.	CO 5, CO 6	T2: 1.1-1.5, T1: 4.1
15	How Tomlinson surface recorded and Talysurf machine work? What are their relative merits?	CO 5, CO 6	T2: 1.1-1.5, T1: 4.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Elementary treatment of metal cutting theory, element of cutting process, geometry of single point tool and angles chip formation and types of chips, built up edge and its effects, chip breakers: Mechanics of orthogonal cutting, Merchant's force diagram, cutting forces, cutting speeds, feed, depth of cut, tool life, coolants, machinability, tool materials.	CO 1	R4:2.1

2	Engine lathe, Principle, specification, types, work and tool holding devices, Automatic lathes, classification: Single spindle and multi-spindle automatic lathes and its tool layouts; Shaping, slotting and planning machines, Principles of working, specification, operations performed, Kinematic scheme.	CO 2	R4:2.1
3	Milling machine, classifications, specifications, working principles of milling machines; Geometry of milling cutters, methods of indexing, kinematic scheme of milling machines. Drilling and boring machines, principles of working, specifications, types, operations performed, twist drill; Kinematics scheme of the drilling and boring machines.	CO 3, CO 4	R4:2.1
4	Systems of Limits and Fits: Introduction, normal size, tolerance limits, deviations, allowance, fits and their types, unilateral and bilateral tolerance system, hole and shaft basis systems, Interchangeability and selective assembly; Linear Measurement: Slip gauges, dial indicator, micrometers; Measurement of angles and tapers: Bevel protractor, angle slip gauges, spirit levels, sine bar.	CO 5	R4:2.1
5	Optical measuring instruments: Tool maker's microscope and its uses, collimators, optical projector, interferometer; Screw thread measurement: Element of measurement, errors in screw threads, measurement of effective diameter, angle of thread and thread pitch, profile thread gauges; Surface roughness measurement: Numerical assessment of surface finish: CLA, R.M.S Values, Rz values, methods of measurement of surface finish: profilograph, talysurf - ISI symbol for indication of surface finish.	CO 6	R4:2.1
	DISCUSSION OF QUESTION BANK		
1	Merchant theory- Orthogonal Cutting forces	CO 1	R4:2.1
2	Tool life based on Taylors new equation	CO 2	T4:7.3
3	Estimation of machine time on lathe operation	CO 3,4	R4:5.1
4	Estimation of machine time on shaper operation	CO 5	T1:7.5
5	Numerical assessment on fits and tolerances	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,ME**

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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**					
Course Title	**THERMAL ENGINEERING**					
Course Code	AMEC20					
Program	B. Tech					
Semester	V					
Course Type	Core					
Regulation	UG20					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	3	1	4	-	-	
Course Coordinator	Dr. Pravat Ranjan Pati, Assistant Professor					

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC06	III	Thermodynamics
B.Tech	AMEC13	IV	Applied Thermodynamics

II COURSE OVERVIEW:

Thermal Engineering is science intended to introduce concepts and working principles of boilers, turbines, condensers and nozzles which are widely used in different industrial applications such as automobile, agriculture, industry for transport, water pumping, electricity generation, earth moving and for supply mechanical power. This course also deals with working principles of aircraft systems such as propulsion systems and rockets in various fields of engineering.

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
16%	Remember
50%	Understand
33%	Apply
0%	Analyze
0 %	Evaluate

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

Alternative Assessment Tool (AAT)

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

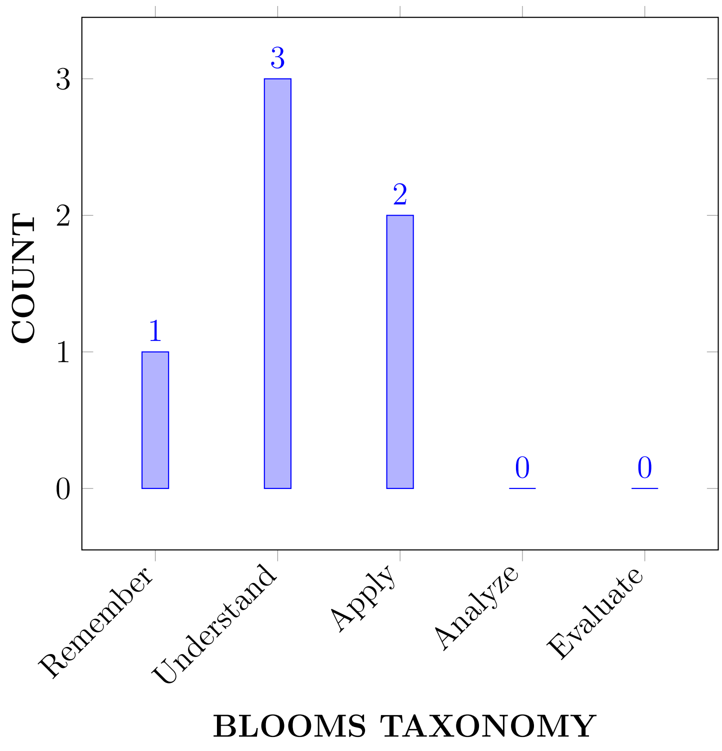
I	The usage of fundamental knowledge on thermodynamic cycles and fluid dynamics phenomena present in turbomachinery and combustion for producing electric and mechanical energy/power.
II	The operational concepts, principles, features, procedures and detailed thermodynamic analyses related to components of power cycles, rocket propulsion as well as steam and power generators.
III	The real-world engineering problems and examples towards gaining the experience for designing and developing power generating systems in engineering practice.

VII COURSE OUTCOMES:

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

CO 1	**Recall** the thermodynamic processes, working and analyses of combustion, vapor power cycles for electrical and mechanical power.	Remember
CO 2	**Interpret** various concepts, principles of operation, theories and phenomena related to the boilers and nozzles.	Understand
CO 3	**Develop** the performance parameters of the steam turbine and reaction turbine for maximum efficiency, thermodynamic analysis of a stage, degree of reaction, velocity diagram.	Apply
CO 4	**Demonstrate** the principles of operation, classification, working, accessories and mountings of various steam generators and condensers.	Understand
CO 5	**Identify** the working principles and analyses of combustion, gas power cycles for producing electrical and mechanical power.	Apply
CO 6	**Demonstrate** the principles, methodologies and variations in the configurations of thermal gas turbomachinery and rocket propulsion based on the availability of resources.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/SEE
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	CIE/SEE
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	CIE/SEE
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	3	CIE/SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2	CIE/SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	2.5	AAT

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall the thermodynamic properties and applications of various laws of thermodynamics in the advanced machines like steam engines, gas turbines and rockets using the knowledge of **mathematics, science** and **engineering fundamental**.	3
	PO 2	Identify and formulate the thermodynamic properties using **first principles** of mathematics, natural sciences, and engineering sciences.	1
	PSO 2	Evaluate the thermodynamic properties using the concepts of **Thermo-Fluid Systems** to provide solutions for **Inter Disciplinary** Engineering Applications.	2
CO 2	PO 1	Explain the concept and working principle of boilers and nozzles using the knowledge of **mathematics**, **science** and **engineering fundamental**.	3
	PO 2	Understand working principle of boilers and nozzles using **first principles** of mathematics, natural sciences, and engineering sciences.	1
	PSO 2	Analyze the working principle of boilers and nozzles using the concepts of **Thermo-Fluid Systems** to provide solutions for **Inter Disciplinary** Engineering Applications.	2
CO 3	PO 1	Explain the concept and working principle of steam turbines using the knowledge of **mathematics**, **science** and **engineering fundamental**.	3
	PO 7	Understand the impact of steam turbines in **societal** and **environmental** contexts, and demonstrate the knowledge of, and need for **sustainable** development.	3
CO 4	PO 1	Explain the concept and working principle of steam condensers using the knowledge of **mathematics**, **science** and **engineering fundamental**.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Understand working principle of steam **condensers** using **first principles** of **mathematics**, **natural sciences**, and **engineering sciences**.	5
	PO 3	Explain the solutions for **complex** Engineering problems and identify the properties of steam **condensers** used for the **public health**, **society**, and **environment**.	5
	PO 6	Apply the working principles of steam condensers in physical systems to assess **societal**, health, safety, legal and **cultural issues** and the consequent responsibilities relevant to the professional **engineering practice**.	3
CO 5	PO 1	Explain the concept and working principle of gas power cycles using the knowledge of **mathematics**, **science** and **engineering fundamental**.	3
	PSO 2	Analyze the working principle of gas power cycles using the concepts of **Thermo-Fluid Systems** to provide solutions for Inter Disciplinary Engineering Applications.	1
CO 6	PO 1	Explain the working principle of turbomachines and rockets using the knowledge of **mathematics**, **science** and **engineering fundamental**.	3
	PO 4	Explain the working principle of **turbomachines** and rockets in physical systems using **research-based knowledge** and research methods including **design of experiments**, **analysis** and **interpretation of data**, and **synthesis** of the information to provide valid **conclusions**.	7
	PO 12	Recognize the major components of the **turbomachines** and **ability** to take part in **independent** and **life-long learning** in the broadest context of **technological** change.	5
	PSO 2	Analyze the working principle of turbomachines and rockets using the concepts of **Thermo-Fluid Systems** to provide solutions for Inter Disciplinary Engineering Applications.	1

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	10	-	-	-	-	-	-	-	-	-	-	-	100	-
CO 2	100	10	-	-	-	-	-	-	-	-	-	-	-	100	-
CO 3	100	-	-	-	-	-	100	-	-	-	-	-	-	-	-
CO 4	100	50	50	-	-	60	-	-	-	-	-	-	-	-	-
CO 5	100	-	-	-	-	-	-	-	-	-	-	-	-	50	-
CO 6	100	-	-	63	-	-	-	-	-	-	-	41	-	50	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 3	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 4	3	2	2	-	-	2	-	-	-	-	-		-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 6	3	-	-	3	-	-	-	-	-	-	-	2	-	2	-
TOTAL	18	4	2	3	-	2	3	-	-	-	-	2	-	10	-
AVERAGE	3	1	2	3	-	2	3	-	-	-	-	2	-	2.5	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

x	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	BASIC CONCEPTS
	Rankine cycle schematic layout, thermodynamic analysis, concept of mean temperature of heat addition, methods to improve cycle performance, regeneration and reheating.
MODULE II	BOILERS AND STEAM NOZZLES
	Boilers: Classification, working principles with sketches, boilers mountings and accessories. Basics of compressible flow, Isentropic flow of a perfect gas through nozzle, subsonic, supersonic and choked flow- normal shocks, flow of steam through nozzles, thermodynamic analysis of nozzle.
MODULE III	STEAM TURBINES AND STEAM CONDENSERS
	Steam Turbines: Classification, Impulse turbine-velocity diagrams, pressure and velocity compounding. Reaction turbine-principle of operation, thermodynamic analysis of a stage, degree of reaction, velocity diagrams. Steam Condensers: Requirements of steam condensing plant, classification of condensers, working principle of different types.
MODULE IV	GAS TURBINES
	Gas turbines: Simple gas turbine plant, ideal cycle, essential components, parameters of performance, actualcycle, regeneration, inter cooling and reheating, closed and Semi-closed cycles, merits and demerits, brief concepts of combustion chambers of gas turbine plant.
MODULE V	JET PROPULSION AND ROCKETS
	Jet propulsion: Principle of operation, classification of jet propulsive engines, working Principles with schematic diagrams and representation on T-S diagram, thrust, thrust power and propulsion efficiency, turbo jet engines, needs and demands met by turbo jet, schematic diagram, thermodynamic cycle, performance evaluation; Rockets: Application, working Principle, classification, propellant type, thrust, propulsive efficiency, specific impulse, solid and liquid propellant rocket engines.

TEXTBOOKS

1. R. K. Rajput, "Thermal Engineering", Lakshmi Publications, 11th Edition, 2020.
2. V. Ganeshan "Gas turbines", Tata McGraw-Hill, 3rd Edition, 2017.

REFERENCE BOOKS:

1. P. Khajuria, S. P Dubey, "Gas Turbines and Propulsive systems", Dhanpat Rai Publishers., 1st Edition, 2012
2. P.L. Ballaney, "Thermal Engineering", Khanna Publishers, 5th Edition, 2017.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112103275

COURSE WEB PAGE:

https://iare.ac.in/sites/default/files/NewRegulationsSyllabi/UG20/B.TECH-MECH-UG20-ACADEMIC-REGULATIONS-AND-COURSE-CATALOG-2020-2021.pdf

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Introduction to Outcome Based Education		
CONTENT DELIVERY (THEORY)			
2	Rankine cycle - Schematic layout	CO 1	T1 1.1
3-4	Thermodynamic Analysis	CO 1	T1 1.2
5-6	Concept of Mean Temperature of Heat addition	CO 1	T1 1.3
7	Methods to improve cycle performance	CO 1	T1 1.4
8-9	Regeneration and reheating	CO 1	T1 1.5
10-12	BOILERS : Classification – Working principles	CO 2	T1 2.1, R1
13-14	Boilers mountings and accessories	CO 2	T1 2.2, R1
15	Function of nozzle – applications- types	CO 2	T1 2.3, R2
16	Flow through nozzles	CO 2	T1 2.4, R1
17	Thermodynamic analysis of nozzle	CO 2	T1 2.5, R1
18	Steam Turbines: Classification	CO 3	T1 3.1, R2
19	Impulse turbine; Mechanical details	CO 3	T1 3.2, R2
20	Velocity diagram – effect of friction – power developed, axial thrust, blade or diagram efficiency	CO 3	T1 3.2, R2
21	condition for maximum efficiency	CO 3	T1 3.3, R2
22	Reaction Turbine: Mechanical details – principle of operation	CO 3	T1 3.4, R2
23	Thermodynamic analysis of a stage, degree of reaction	CO 3	T1 3.5, R2
24	Velocity diagram Parson's reaction turbine – condition for maximum efficiency	CO 3	T1 3.5,R2
25	Steam Condensers : Requirements of steam condensing plant	CO 4	T1 3.6, R1
26	Classification of condensers, working principle of different types	CO 4	T1 3.7, R1
27-29	Gas Turbines: Simple gas turbine plant, Ideal cycle, essential components – parameters of performance, actual cycle	CO 5	T1 4.1, R3
30-32	Regeneration, inter cooling and reheating	CO 5	T1 4.2, R3
33	Closed and Semi-closed cycles – merits and demerits	CO 5	T1 4.3, R3

34	Brief concepts of combustion chambers of gas turbine plant	CO 5	T1 4.3, R3
35-36	Jet propulsion: Principle of Operation, Classification of jet propulsive engines, Working Principles with schematic diagrams and representation on T-S diagram	CO 6	T1 4.4, R3
37	Thrust, Thrust Power and Propulsion Efficiency	CO 6	T1 4.5, R3
38-39	Turbo jet engines – Needs and Demands met by Turbo jet – Schematic Diagram, Thermodynamic Cycle, and Performance Evaluation	CO 6	T1 4.7, R3
40	Rockets: Application – Working Principle – Classification – Propellant Type – Thrust, Propulsive Efficiency – Specific Impulse	CO 6	T1 4.9, R3
41	Solid and Liquid propellant Rocket Engines.	CO 6	T1 4.11, R3
PROBLEM SOLVING/ CASE STUDIES			
42	A Rankine cycle operates between pressures of 80 bar and 0.1 bar. The maximum cycle temperature is 600°C. If the steam turbine and condensate pump efficiencies are 0.9 and 0.8 respectively, calculate the specific work and thermal efficiency.	CO 1	T1 1.1
43	A simple Rankine cycle works between pressures 28 bar and 0.06 bar, the initial condition of steam being dry saturated. Calculate the cycle efficiency, work ratio and specific steam consumption.	CO 1	T1 1.2
44	A steam power plant operates on a theoretical reheat cycle. Steam at boiler at 150 bar, 550°C expands through the high pressure turbine. It is reheated at a constant pressure of 40 bar to 550°C and expands through the low pressure turbine to a condenser at 0.1 bar. Draw T-s and h-s diagrams. Find: (i) Quality of steam at turbine exhaust; (ii) Cycle efficiency ; (iii) Steam rate in kg/kWh.	CO 1	T1 1.3
45	Steam is expanded in a set of nozzles from 10 bar and 200ºC to 5 bar. What type of nozzle is it ? Neglecting the initial velocity find minimum area of the nozzle required to allow a flow of 3 kg/s under the given conditions. Assume that expansion of steam to be isentropic.	CO 2	T1 2.4
46	Steam is expanded in a set of nozzles from 10 bar and 250° C to 5 bar. What type of nozzle is it? Assume the expansion to be isentropic.	CO 2	T1 2.4
47	In a steam nozzle, the steam expands from 4 bar to 1 bar. The initial velocity is 60 m/s and the initial temperature is 200°C. Determine the exit velocity if the nozzle efficiency is 92 percent.	CO 2	T1 2.5
48	The velocity of steam exiting the nozzle of the impulse stage of a turbine is 400 m/s. The blades operate close to the maximum blading efficiency. The nozzle angle is 20°. Considering equiangular blades and neglecting blade friction, calculate for a steam flow of 0.6. kg/s, the diagram power and the diagram efficiency.	CO 3	T1 3.4

49	A single stage steam turbine is supplied with steam at 5 bar, 200°C at the rate of 50 kg/min. It expands into a condenser at a pressure of 0.2 bar. The blade speed is 400 m/s. The nozzles are inclined at an angle of 20° to the plane of the wheel and the outlet blade angle is 30°. Neglecting friction losses, determine the power developed, blade efficiency, and stage efficiency.	CO 3	T1 3.5
50	Steam enters a condenser at 36°C and with barometer reading 760 mm. If the vacuum of 695 mm is produced find the vacuum efficiency.	CO 4	T1 3.7
51	A gas turbine plant receives air at 1 bar and 290 K and compresses it to 5 bar, If the temperature of air after compression is 1000 K ; find the thermal efficiency of the turbine.	CO 5	T1 4.1
52	A simple closed cycle gas turbine plant receives air at 1 bar and 15° C, and compresses it to 5 bar and then heats it to 800° C in the heating chamber. The hot air expands in a turbine back to 1 bar. Calculate the power developed per kg of air supplied per second. Take Cp for the air as 1 kJ/kg K.	CO 5	T1 4.3
53	A gas turbine plant consists of two stage compressor with perfect intercooler and a single stage turbine. If the plant works between the temperature limits of 300 K and 1000 K and 1 bar and 16 bar, determine the net power of the plant per kg of air. Take specific heat constant pressure as 1 kJ/kg K.	CO 5	T1 4.1
54	A turbojet is flying with a velocity of 320 m/s at an altitude of 9150m, where the ambient conditions are 32 kPa and -32°C. The pressure ratio across the compressor is 12, and the temperature at the turbine inlet is 1400 K. Air enters the compressor at a rate of 40 kg/s, and the jet fuel has a heating value of 42,700 kJ/kg. Assuming ideal operation for all components and constant specific heats for air at room temperature, determine: a) the temperature and pressure at the turbine exit, b) the velocity of the exhaust gases, c) the propulsive power developed	CO 6	T1 4.9
55	An aircraft flies at a speed of 520 kmph at an altitude of 8000 m. The diameter of the propeller of an aircraft is 2.4 m and flight to jet speed ratio is 0.74. density is 0.525 kg/m3.Find the following: (i) The rate of air flow through the propeller, (ii) Thrust produced, (iii) Specific thrust, (iv) Specific impulse, (v) Thrust power	CO 6	T1 4.9

56	A turbo-jet engine travels at 216 m/s in air at 0.78 bar and – 7.2°C. Air first enters diffuser in which it is brought to rest relative to the unit and it is then compressed in a compressor through a pressure ratio of 5.8 and fed to a turbine at 1110°C. The gases expand through the turbine and then through the nozzle to atmospheric pressure (i.e., 0.78 bar). The efficiencies of diffuser, nozzle and compressor are each 90 percent. The efficiency of turbine is 80 percent. Pressure drop in the combustion chamber is 0.168 bar. Determine: (i) Air-fuel ratio, (ii) Specific thrust of the unit, (iii) Total thrust, if the inlet cross-section of diffuser is 0.12 m2. Assume calorific value of fuel as 44150 kJ/kg of fuel.	CO 6	T1 4.9
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Rankine cycle, thermodynamic analysis, regeneration, reheating	CO 1	T1 1.1
58	Boilers, steam nozzles, compressible flow, Isentropic flow, thermodynamic analysis of nozzle	CO 2	T1 2.2
59	Impulse turbine, Reaction turbine, velocity diagrams, Steam Condensers	CO 3, 4	T1 3.1
60	Simple gas turbine plant, ideal cycle, closed and semi-closed cycles, combustion chambers	CO 5	T1 4.1
61	Turbo jet engines, thrust, thrust power, propulsion efficiency solid and liquid propellant rocket engines	CO 6	T1 4.9
DISCUSSION OF QUESTION BANK			
62	Module I: Basic concepts, Rankine cycle	CO 1	T1 1.1
63	Module II: Boilers and steam nozzles	CO 2	T1 2.2
64	Module III: Steam turbines and steam condensers	CO 3, 4	T1 3.1
65	Module IV: Gas turbines: Simple gas turbine plant	CO 5	T1 4.1
66	Module V: Jet propulsion and rockets	CO 6	T1 4.9

Signature of Course Coordinator **HOD, ME**
Dr. Pravat Ranjan Pati, Assistant Professor

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

COURSE DESCRIPTION

Department	**Mechanical Engineering**				
Course Title	**Business Economics and Financial Analysis**				
Course Code	AHSC13				
Program	B.Tech				
Semester	V				
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. M Sindu, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

II COURSE OVERVIEW:

The present course is designed in such a way that it gives an overview of concepts of Economics. Managerial Economics enables students to understand micro environment in which markets operate how price determination is done under different kinds of competitions. Financial Analysis gives clear idea about concepts, conventions and accounting procedures along with introducing students to fundamentals of ratio analysis and interpretation of financial statements. Break Even Analysis is very helpful to the Business Concern for Decision Making, controlling and forward Strategic Planning. Ratio analysis gives an idea about financial forecasting, financial planning, controlling the business and decision making.

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
16.67%	Remember
16.67%	Understand
16.67%	Apply
50 %	Analyze
0 %	Evaluate
0 %	Create

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

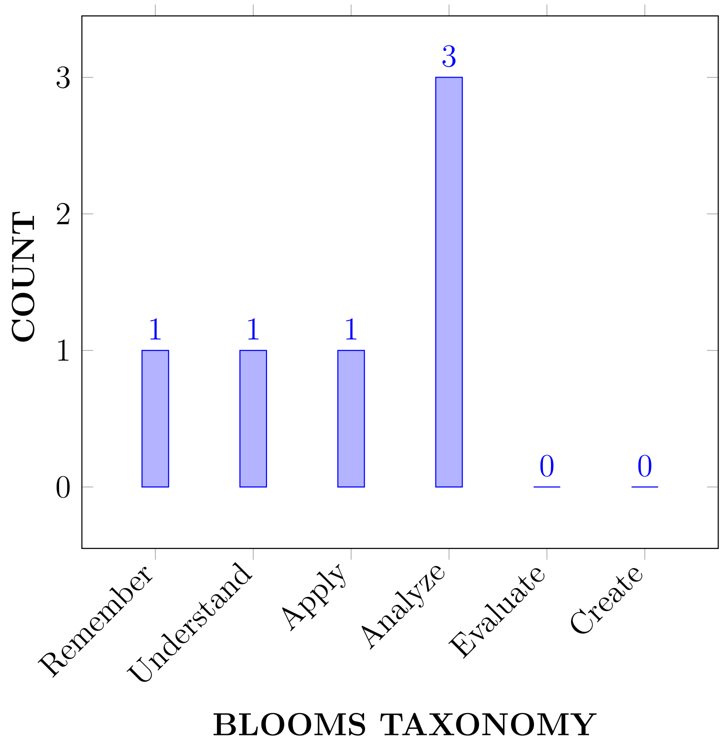
I	The concepts of business economics and demand analysis helps in optimal decision making in business environment
II	The functional relationship between Production and factors of production and able to compute breakeven point to illustrate the various uses of breakeven analysis.
III	The features, merits and demerits of different forms of business organizations existing in the modern business environment and market structures.
IV	The concept of capital budgeting and allocations of the resources through capital budgeting methods and compute simple problems for project management.
V	Various accounting concepts and different types of financial ratios for knowing financial positions of business concern.

VII COURSE OUTCOMES:

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

CO 1	**List** the basic concepts of managerial economics and analysis, measurement of demand and its forecasting to know the current status of goods and services.	Remember
CO 2	**Examine** to know the current status of goods and services. to know the economies and diseconomies of scale in manufacturing sector.	Analyze
CO 3	**Summarize** the four basic market models like perfect competition, monopoly, monopolistic competition, and oligopoly to know the price and quantity are determined in each model.	Understand
CO 4	**Compare** various types of business organizations and discuss their implications for resource allocation to strengthen the market environment.	Analyze
CO 5	**Analyze** different project proposals by applying capital budgeting techniques to interpret the solutions for real time problems in various business projects.	Analyze
CO 6	**Develop** the ability to use a basic accounting system along with the application of ratios to create (record, classify, and summarize) the data needed to know the financial position of the organization.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	1	Seminar/ Conferences
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	Assignments/ Discussion
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	3	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining	-	-
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications	-	-
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies	-	-

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Recall** (knowledge) the scientific fundamentals of economic activities performed by the businessmen in the business for profit earning.	2
	PO 2	**Interpret** and identify the demand and its analysis with the mathematical and natural principles of demand forecasting methods.	6
	PO 8	**Define** (knowledge) the responsibilities of the engineering practices by knowing the best economical practices.	1
	PO 9	**Match** (knowledge) the economical implication to effectively function as a team member, and as a member or leader in diverse teams.	5

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 11	**Relate** (knowledge) the knowledge and understanding of the economic principles and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	6
CO 2	PO 1	**Recall** (Knowledge) the knowledge of mathematics, science in the production function through Different Combination of variable inputs with Economies of Scale.	2
	PO 2	**Demonstrate** the different cost concepts and determine the significance of Break Even Analysis.	5
	PO 8	**Relate** (Knowledge) (Knowledge) the ethical principles and commit to professional ethics and responsibilities and norms of the production management	2
	PO 9	**Show** (Fundamentals) the production function implications for effective implementation of gang compositions in a team work and in multidisciplinary settings.	6
	PO 11	**Define** the economies of scale in production function and Break Even Analysis knowledge applied in one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	5
CO 3	PO 8	**List** (Knowledge) (Knowledge) different structures of market and how price is determined under different market structures commit to professional ethics and responsibilities and norms of the engineering practice.	2
	PO 9	**Match** the market structures and the market entry strategies as an individual, and as a member in diverse teams.	6
CO 4	PO 8	**Categorize** the ethical principles and commit to professional ethics and responsibilities belongs to different forms of business organizations existing in the modern business.	2
	PO 9	**Classify** various business organizations and their functioning as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	6
CO 5	PO 1	**Explain** the ethical issues involved in the allocation of funds under the concept of capital budgeting.	1
	PO 11	**Summarize** the concept of capital budgeting and allocations of the resources through capital budgeting methods of the management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	8
CO 6	PO 2	**Explain** the GAAP principles and ratios to analyse complex engineering problems reaching substantiated conclusions using first principles of accounts and profitability and efficiency of the organization.	6

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 11	**Illustrate**the accounting methods and procedures and accounting principles to manage the financial aspects in a project.	8

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	60.0	-	-	-	-	-	33.3	41.6	-	50.0	-	-	-	-
CO 2	66.7	50.0	-	-	-	-	-	66.7	50.0	-	41.6	-	-	-	-
CO 3	-	-	-	-	-	-	-	66.7	50.0	-	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	66.7	50.0	-	-	-	-	-	-
CO 5	33.3	-	-	-	-	-	-	-	-	-	75.0	-	-	-	-
CO 6	-	20.0	-	-	-	-	-	-	-	-	75.0	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 6	-	1	-	-	-	-	-	-	-	-	3	-	-	-	-
TOTAL	7	7	-	-	-	-	-	10	8	-	-	-	-	-	-
AVERAGE	2.3	2.3	-	-	-	-	-	2.5	2	-	2.5	-	-	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

X	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION&DEMAND ANALYSIS**
	Introduction to Business Economics: Definition, Nature and Scope of Managerial Economics – Demand Analysis: Demand Determinants, Law of Demand and its exceptions. Elasticity of Demand: Definition, Types, Measurement and Significance of Elasticity of Demand. Demand Forecasting, Factors governing demand forecasting, methods of demand forecasting
MODULE II	**PRODUCTION & COST ANALYSIS**
	Theory of Production and Cost Analysis: Production Function – Iso-quants and Iso-costs, MRTS, Least Cost Combination of Inputs, Cobb-Douglas Production function, Laws of Returns, Internal and External Economies of Scale. Cost Analysis: Cost concepts; Break-even analysis, Determination of Break – Even point (Simple Problems) , Managerial Significance of BEA.
MODULE III	**MARKETS & NEW ECONOMIC ENVIRONMENT**
	LMarket structures: Types of competition, Features of perfect competition, Monopoly and monopolistic competition. Price determination & Price Statistics: Price Output determination in case of perfect competition and monopoly. Features and evaluation of different forms of Business organization: Sole proprietorship, partnership, Joint Stock Company, public enterprises and their types.
MODULE IV	**CAPITAL BUDGETING**
	Capital and its significance, types of capital, estimation of fixed and working capital requirements, methods and sources of raising capital- Trading Forecast, Capital budget, Cash Budget. Features of capital budgeting proposals, methods of capital budgeting – payback method, Accounting rate of return(ARR), Net Present Value Method (simple problems).

MODULE V	**INTRODUCTION TO FINANCIAL ACCOUNTING AND FINANCIAL ANALYSIS**
	Financial accounting objectives, functions, importance; Accounting concepts and accounting conventions - double-entry book keeping, journal, ledger, trial balance; Final accounts: Trading account, profit and loss account and balance sheet with simple adjustments; Financial analysis: Analysis and interpretation of liquidity ratios, activity ratios, capital structure ratios and profitability ratios (simple problems), Du Pont chart.

TEXTBOOKS

1. Aryasri, “Managerial Economics and Financial Analysis”, TMH publications, 4thEdition,2012.
2. M. KasiReddy, Saraswathi, “Managerial Economics and Financial Analysis”, PHI Publications, New Delhi, 2ndEdition,2012.
3. Varshney, Maheswari, “Managerial Economics”, Sultan Chand Publications, 11thEdition,2009.

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1. D.N. Dwivedi, “Managerial Economics”, Vikas Publication House Pvt.Ltd, 2ndEdition,2012.
2. S.N. Maheshwari & S.K.Maheshwari, “Financial Accounting”, Vikas Publication House Pvt.Ltd,4thEdition, 2012.
3. R.NarayanaSwamy, “Financial Accounting- A managerial Perspective”, Pearson publications, 1stIndian Reprint Edition,2012.

WEB REFERENCES:

1. https://courses.lumenlearning.com/boundless-marketing/chapter/demand-analysis/
2. https://theintactone.com/2019/10/01/me-u3-topic-2-cost-output-relationship-in-short-run-long-run-cost-curves/
3. https://corporatefinanceinstitute.com/resources/knowledge/modeling/break-even-analysis/
4. https://corporatefinanceinstitute.com/resources/knowledge/economics/market-structure/#: :text=The%20four%20popular%20types%20of,monopoly%20market%2C%20and%20mo
5. https://www.vedantu.com/commerce/various-forms-of-business-organisations
6. https://courses.lumenlearning.com/boundless-finance/chapter/introduction-to-capital-budgeting/
7. https://jkbhardwaj.com/20-transactions-with-their-journal-entries-ledger-and-trial-balance/
8. https://www.iedunote.com/write-accounting-ledger
9. https://opentextbc.ca/principlesofaccountingv1openstax/chapter/prepare-a-trial-balance/
10. https://caknowledge.com/how-to-prepare-final-accounts/
11. https://corporatefinanceinstitute.com/resources/knowledge/finance/ratio-analysis/

COURSE WEB PAGE:

https://lms.iare.ac.in/index?route=publicprofile&id=5201

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Discussion on Course Outcomes and how these COs mapped with POs and PSOs.		
CONTENT DELIVERY (THEORY)			
2-3	Explain about managerial economics according to the business	CO 1	T1- 1.3-1.8 R1-1.5-1.7
4-5	Describe about demand analysis, the Law of Demand and Demand Function.	CO 1	T1-2.2-2.11 R1-3.3-3.20
6-7	Understand elasticity of the demand of the product, different types, Measurement of Elasticity of Demand and Factors influencing on Elasticity of Demand.	CO 1	T1-3.3-3.20 R1- 5.29-6.8
8	State different methods of Demand Forecasting and the factors governing Demand Forecasting.	CO 1	T1-4.6-4.19
9-10	Demonstrate the Production function, features of Iso-Quants and Iso-Costs, different types of Internal Economies, External Economies and Law of Returns.	CO 2	T1- 5.3-5.18 R1- 5.29-6.8
11-13	Different types of Internal Economies, External Economies ad Law of Returns with appropriate examples.	CO 2	T1- 5.3-5.18
14-15	Illustrate different types of costs	CO 2	T1- 5.29-6.8
16-17	Explain the Significance and Limitations of Break-Even Analysis	CO 2	T1- 7.13-7.14
18-19	Calculate Break-Even Point (Simple Problems)	CO 2	T1- 7.1-7.12
20-21	Illustrate the features, price-output determination under Perfect Competition, Monopoly and Monopolistic competition Markets.	CO 3	T1- 8.4-8.16 R2- 5.29-6.8
22-24	Demonstrate the Objectives, Policies and Methods of Pricing Strategies and Price Methods.	CO 3	T1- 8.21-8.25
25-26	Describe Features of business, Definitions of Various forms of Business Units.	CO 4	T1-9.3-9.15
27-30	State the Merits & Demerits of Different types of Public Enterprises and Changing Business Environment to Post Liberalization Scenario.	CO 4	T1-9.2-10.23 R1- 8.21-8.25
31-32	Explain the significance and classification of capital, Methods and Sources of Raising Finance.	CO 6	T1-9.2-10.23
33-34	Demonstrate the concept of capital budgeting and allocations of the resources through capital budgeting methods and compute simple problems.	CO 6	T1-11.3-11.5 R2-12.3-12.5
35-37	Illustrate the Significance of Financial Accounting, Double Entry, Accounts, Accounting Concepts and Conventions	CO 6	T1-12.1-12.26
38-40	Explain the meaning, advantages and Limitations of the Journal, Ledger and Trial Balance and Final Accounts and Solve simple Problems.	CO 6	T1-13.4-13.15 R2-11.3-11.5
41-42	Describe Meaning, Definitions and Limitations of Ratio Analysis	CO 6	T1-13.4-13.15 R2-11.7-11.8

43-45	Compute different types of Financial Ratios (Problems)	CO 6	T1-13.5-13.68
PROBLEM SOLVING/ CASE STUDIES			
46	Problems relating to Demand elasticty measurement and Forecasting	CO 1	T1: 1.1 - 2.8, R1:2.1
47	Problems relation to Break Even Point	CO 2	T2: 3.0 to 3.6, 5.0 to5.5 , R2:4.4
48	Problems in determining the price in different types of markets	CO 3,4	T3: 6.0 to 6.4, R1:5.1
49	Problems relating to Capital Budgeting Decisions	CO 5	R2:7.5
50	Problems relating to Final Accounts and Calculation of Ratios	CO 6	R3: 4.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
51	Introduction and Demand Analysis	CO 1	T1: 1.1 - 2.8, R1:2.1
52	Production and Cost Analysis	CO 2	T2: 3.0 to 3.6, 5.0 to5.5 , R2:4.4
53	Markets and New Environment	CO 3,4	T3: 6.0 to 6.4, R1:5.1
54	Capital Budgeting	CO 5	R2:7.5
55	Introduciton to Financial Accounting and Financial Analysis	CO 6	R3: 4.1
DISCUSSION OF QUESTION BANK			
56	Introduction and Demand Analysis	CO 1	T1: 1.1 - 2.8, R1:2.1
57	Production and Cost Analysis	CO 2	T2: 3.0 to 3.6, 5.0 to5.5 , R2:4.4
58	Markets and New Environment	CO 3,4	T3: 6.0 to 6.4, R1:5.1
59	Capital Budgeting	CO 5	R2:7.5
60	Introduciton to Financial Accounting and Financial Analysis	CO 6	R3: 4.1

Signature of Course Coordinator **HOD,MBA**
Dr. M Sindu, Associate Professor

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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**ENGINEERING TRIBOLOGY**				
Course Code	AMEC24				
Program	B.Tech				
Semester	V				
Course Type	ELECTIVE				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr.B.VijayaKrishna ,Assistant Professor.				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSC06	II	Chemsitry
B.Tech	AMEC01	II	Engineering Mechanics
B.Tech	AMEC07	III	Material Engineering

II COURSE OVERVIEW:

Engineering tribology explores the latest innovations in the study of friction,wear,and lubrication to solve practical manufacturing challenges in order to take a deep dive into tribology trends and strategies, including those related to surface energy.Tribology is the art of applying operational analysis to problems of great economic significance, namely, reliability, maintenance, and wear of technical equipment, ranging from spacecraft to household appliances Tribological knowledge helps in reducing the requirement of maintenance and improves reliability of interacting machine components. Essence of tribology at design stage yields substantial economic benefits.The different lubricant standards and its applications in the industries are addressed.

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
30 %	Remember
40 %	Understand
30 %	Apply
0 %	Analyze

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

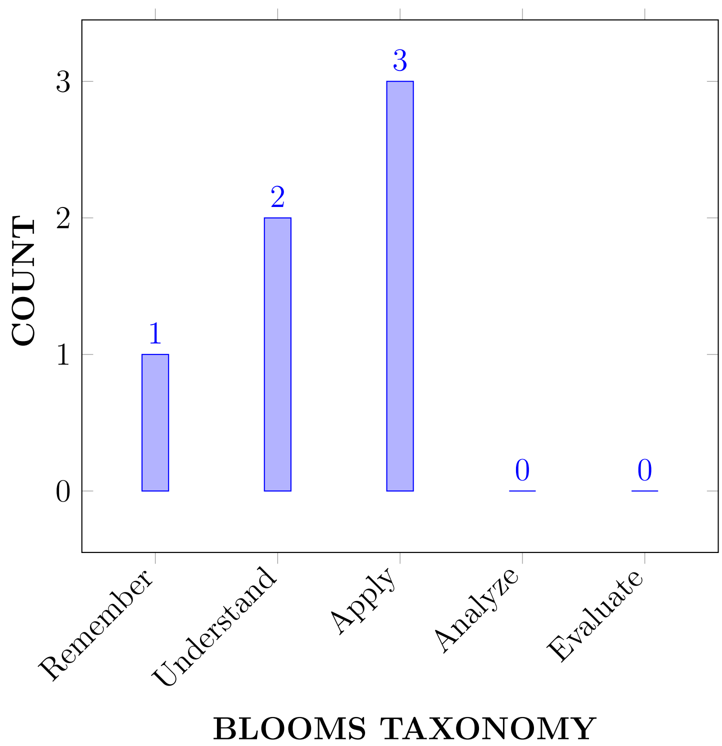
I	To provide the knowledge and importance of Tribology in Design, friction, wear and lubrication aspects of machine components.
II	To select proper grade lubricant for specific application.
III	To understand the principles of lubrication, lubrication regimes, theories of hydrodynamic and the advanced lubrication techniques.
IV	To introduce the concept of surface engineering and its importance in tribology

VII COURSE OUTCOMES:

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

CO 1	**Demonstrate** surface topography, physio-chemical aspects of solid surfaces, and surface interactions of metallic and non-metallic materials to understand the nature of function.	Understand
CO 2	**Make use** the laws of friction, mechanisms of friction, friction space and surface temperature for tribological applications.	Apply
CO 3	**List** the various types of wears and wear measurements techniques.	Remember
CO 4	**Identify** lubrication regimes based on nature of contact using lubrication standards such as ISO, SAE, AGMA, BIS standards and its applications.	Apply
CO 5	**Outline** the importance of tribology in minimizing the factors influencing corrosion for protecting the surface coating applications	Understand
CO 6	**Select** the appropriate materials and its alloys based on composition for tribological applications	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	3	Quiz
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	2	Quiz

3 = High; 2 = Medium; 1 = Low

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

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

XII JUSTIFICATIONS FOR CO PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Develop Surface topology of different materials,properties and measure interaction by applying the knowledge of mathematics, science and Engineering Fundamentals	3
	PO 3	Develop a relevant surface interaction for materials to find sliding friction,rolling friction and other frictional properties that meets the specific needs of safety and environmental considerations	2
	PO 6	Extend the theory of friction for metal and non metal materials by contextual knowledge to access safety and the consequent responsibility relevant to professional engineering practices.	1
	PO 7	Understand the impact of surface interactions in metallic and non metallic materials in extreme conditions for engineering solutions and environmental context for sustainable development	2
	PSO1	Ability to apply principle of friction and surface topology for machining of complex design	1
CO 2	PO 1	Identify the types of wears for different mechanisms using the knowledge of mathematics,science and engineering fundamentals for specialised applications in surface treatments.	3
	PS01	develop a resource to identify wear during high speed machining process during international standards of friction and wear measurements	1
CO 3	PO 1	Make use of lubricating properties for different materials by applying the knowledge of mathematics, science and engineering fundamentals for dynamic conditions of machining.	3
	P0 4	Identify research methods for boundary lubrication to design experiments,analyze and interpretation of results to provide valid conclusions in dynamic lubrication's.	4

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PS0 1	Identify suitable method for application of lubrication during high speed machining condition.	1
CO 4	PO 1	Lists out different types of corrosion's,factors influencing corrosion during selection of materials by applying knowledge of engineering fundamentals	1
CO 5	PO 1	Identify the factors influencing corrosion on materials by the knowledge of engineering fundamentals	1
	P0 2	Relate various factor influencing corrosion to identify ,formulate,complex engineering problems for protection of different materials .	3
CO 6	PO 1	Select the materials and its alloys based on tribological applications by applying the knowledge of science,engineering fundamentals for engineering material selection .	2

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO PO/ PSO

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

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	2	-	-	1	2	-	-	-	-	-	1	-	
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 3	3	-	-	4	-	-	-	-	-	-	-	-	1	-	-
CO 4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	13	3	2	4	-	1	2	-	-	-	-	-	3	-	-
AVERAGE	2	1	2	3	-	1	2	-	-	-	-	-	1	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

x	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**SURFACE INTERACTION AND FRICTION**
	Topography of Surfaces, Surface features-Properties and measurement, Surface interaction, Adhesive Theory of Sliding Friction, Rolling Friction, Friction properties of metallic and non-metallic materials, friction in extreme conditions, Thermal considerations in sliding contact
MODULE II	**WEAR AND SURFACE TREATMENT**
	Types of wear, Mechanism of various types of wear, Laws of wear, Theoretical wear models, Wear of Metals and Non metals, Surface treatments, Surface modifications, surface coatings methods, International standards in friction and wear measurements
MODULE III	**LUBRICANTS AND LUBRICATION REGIMES**
	Lubricants and their physical properties, Viscosity and other properties of oils, Additives-and selection of Lubricants, Lubricants standards ISO, SAE, AGMA, BIS standards. Lubrication Regimes, Solid Lubrication, Dry and marginally lubricated contacts, Boundary Lubrication Hydrodynamic lubrication, Elasto and plasto hydrodynamic, Hydro static lubrication.

MODULE IV	**CORROSION**
	Introduction, Principle of corrosion , Classification of corrosion, Types of corrosion, Factors influencing corrosion, Testing of corrosion, Evaluation of corrosion, Prevention of Corrosion, Material selection, Alteration of environment, Cathodic and Anodic Protection.
MODULE V	**ENGINEERING MATERIALS**
	Introduction, Advanced alloys, Super alloys, Titanium alloys, Magnesium alloys, Aluminium alloys, and Nickel based alloys, Ceramics, Polymers, and Applications.

TEXTBOOKS

1. G.W.Stachowiak A.W .Batchelor , Engineering Tribology, Butterworth-Heinemann, UK,2018.
2. E.Rabinowicz, Friction and Wear of materials, John Willey Sons,UK,2015.

REFERENCE BOOKS:

1. S.K.Basu, S.N.Sengupta B.B.Ahuja ,Fundamentals of Tribology, Prentice Hall of India Pvt Ltd , New Delhi, 2019.
2. J.A.Williams,Engineering Tribology, Oxford Univ. Press, 2018.

WEB REFERENCES:

1. http:www.tribology-abc.com
2. https:ocw.mit.edu/courses/mechanical-engineering/2-800-tribology-fall-2004/index.htm

COURSE WEB PAGE:

Engineering Tribology (UG-20) Akasnsha Learning Management System B.Vijaya krishna

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
	OBE DISCUSSION		
1	Course Description on outcome Based Education (OBE) : Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
	CONTENT DELIVERY (THEORY)		
2	Topography of Surfaces	C01	T1: 1.2-1.4, T1: 4.1
3	Surface Interaction	C01	T2: 1.1-1.5, T1: 4.1
4	Adhesive Theory of Sliding Friction	C02	T1: 1.8-1.9, T1: 4.1
5	Friction properties of metallic and non-metallic materials	C02	T2: 2.3-2.7, T1: 4.1
6	Friction in extreme conditions	C02	T2: 3.6-3.7, T1: 4.1

7	Thermal considerations in sliding contact	C02	T2: 2.1-2.5, T1: 3.1
8	Types of wear	C03	T2: 4.1-4.5, T1: 2.1
9	Mechanism of various types of wear	C03	T2: 3.1-3.5, T1: 5.1
10	Laws of wear	C03	T2: 1.1-1.5, T1: 4.2
11	Theoretical wear models	C03	T2: 4.1-4.5, T1: 4.3
12	Wear of Metals and Non metals	C03	T2: 1.1-1.5, T1: 4.8
13	Surface treatments	C03	T2: 1.1-1.7, T1: 5.1
14	Surface modifications	C03	T2: 1.1-1.8, T1: 5.9
15	surface coatings method	C03	T2: 1.6-1.9, T1: 3.1
16	International standards in friction and wear measurements	C03	T2: 2.1-.5, T1: 5.1
17	Lubricants and their physical properties,	C04	T2: 1.3-1.5, T1: 4.1
18	Viscosity and other properties of oils	C04	T2: 1.4-1.5, T1: 3.1
19	Additives-and selection of Lubricants	C04	T2: 4.1-4.5, T1: 2.1
20	Lubricants standards ISO, SAE, AGMA, BIS standards	C04	T2: 1.1-1.5, T1: 6.1
21	Lubrication Regimes	C04	T2: 3.8-3.9, T1: 3.1
22	Solid Lubrication	C04	T2: 7.1-7.5, T1: 9.1
23	Dry and marginally lubricated contacts,	C04	T2: 6.1-6.5, T1: 5.1
24	Boundary Lubrication	C04	T2: 9.1-5.5, T1: 8.1
25	Hydrodynamic lubrication	C04	T2: 4.3-4.9, T1: 2.1
26	Elasto and plasto hydrodynamic	C04	T2: 10.1-10.5, T1: 10.1
27	Hydro static lubrication.	C04	T2: 10.1-10.5, T1: 4.1
28	Principle of corrosion	C05	T2: 1.1-1.5, T1: 40.1

29	Classification of corrosion	C05	T2: 10.1-10.5, T1: 4.1
30	Types of corrosion	C05	T2: 9.1-9.5, T1: 9.1
31	Factors influencing corrosion	C05	T2: 8.1-8.5, T1: 4.3
32	Testing of corrosion	C05	T2: 4.1-4.5, T1: 2.2
33	Evaluation of corrosion	C05	T2: 1.1-1.5, T1: 4.4
34	Prevention of Corrosion	C05	T2: 1.1-1.5, T1: 4.9
35	Material selection,	C06	T2: 7.1-7.5, T1: 6.1
36	Alteration of environment	C06	T2: 2.1-2.5, T1: 5.1
37	Cathodic and Anodic Protection	C06	T2: 5.1-5.5, T1: 4.1
38	Advanced alloys, Super alloys, Titanium alloys	C06	T2: 6.1-6.5, T1: 4.1
39	Magnesium alloys, Aluminium alloys, and Nickel based alloys	C06	T2: 1.1-1.5, T1: 4.1
40	Ceramics, Polymers, and Applications	C06	T2: 1.1-1.5, T1: 4.1
PROBLEM SOLVING/ CASE STUDIES			
1	Rolling Friction	CO2	R1:7.7
2	Friction properties of metallic and non-metallic materials	CO2	R2:6.5
3	Thermal considerations in sliding contact	CO2	R2:7.8
4	Laws of wear	CO3	R1:4.5
5	Wear of Metals and Non metals	CO3	R2:7.5
6	International standards in friction and wear measurements	CO3	R2:5.5
7	Viscosity and other properties of oils	CO4	R2:3.5
8	Solid Lubrication	CO4	R2:1.5
9	Boundary Lubrication	CO4	R2:6.1
10	Hydrodynamic lubrication	CO4	R2:1.5
11	Evaluation of corrosion,	CO5	R2:7.1
12	Cathodic and Anodic Protection	CO5	R2:1.23
13	Advanced alloys, Super alloys	CO6	R2:8.3
14	Titanium alloys, Magnesium alloys, Aluminium alloys, and Nickel based alloys	CO6	R2:8.8
15	Ceramics, Polymers, and Applications	CO6	R2:8.9

DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Surface Interaction and Friction	CO1,CO2	R1:2.1
2	Wear and Surface Treatment	CO3	R1:2.1
3	Lubricants and Lubrication Regimes	CO4	R2:2.1
4	Corrosion	CO5	R4:2.1
5	Engineering Materials	CO6	R2:5.4
DISCUSSION OF QUESTION BANK			
1	Module I: Surface Interaction and Friction	CO1,CO2	R2:4.1
2	Module II: Wear and Surface Treatment	CO 3	T4:7.3
3	Module III:Lubricants and Lubrication Regimes	CO4	R4:5.1
4	Module IV: Corrosion	CO5	T1:7.5
5	Module V: Engineering Materials	CO6	T1: 4.1

Signature of Course Coordinator **HOD,ME**
Mr.B.Vijayakrishna , Assistant Professor

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

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	MACHINE TOOLS AND METROLOGY LABORATORY				
Course Code	AMEC25				
Program	B.Tech				
Semester	V				
Course Type	Laboratory				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Dr. K. Ch Apparao, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AMEC19	III	Machine Tools and Metrology

II COURSE OVERVIEW:

Manufacturing is the production of goods through the use of labour, machinery and tools. This course introduces the mechanism of metal cutting of different geometrical shapes using wide variety of cutting tools. This emphasizes on the development/ demand of the newer materials with cutting edge technology tools. It is designed to impart the practical knowledge about the various machining processes like turning, shaping, planning, drilling, milling and grinding to produce desired shape of a product. This course introduces the metrological equipment to measure form and positional accuracy of manufactured/machined components and to interpret the results.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Machine Tools and Metrology Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

The emphasis on the experiments is broadly based on the following criteria given in Table: 1

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

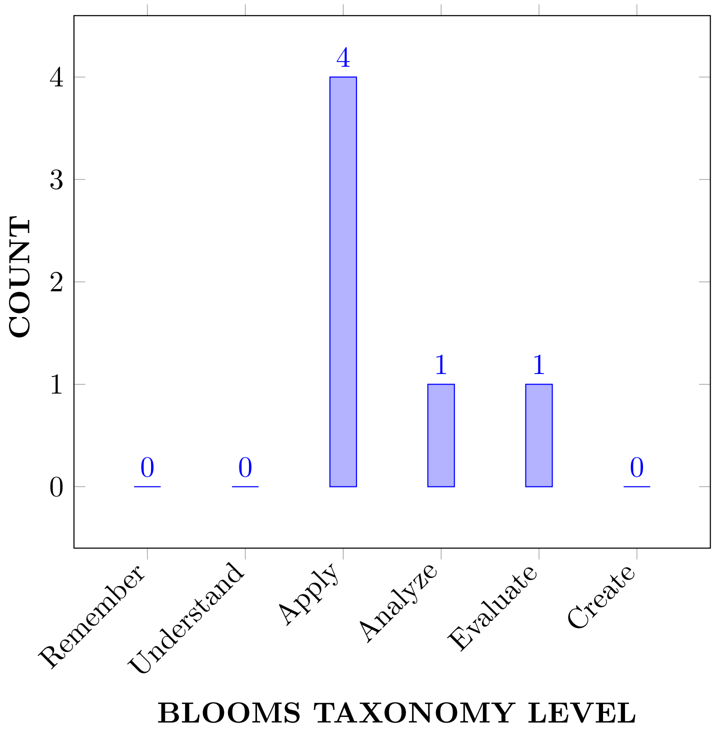
I	The empirical knowledge on machine tools so that they can identify, manipulate and control various process parameters during machining processes in the manufacturing industry.
II	The details related to thermal aspects during machining for defect free manufacturing components.
III	The mechanics of machining process and significance of various process parameters in order to yield the optimum machining.
IV	The principles of linear and angular measuring instruments for accurate measurement of a given component.

VII COURSE OUTCOMES:

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

CO 1	**Apply** the appropriate cutting parameters for prismatic operations and their critical tool development/selection of Lathe, Milling, drilling, slotting shaping and surface grinding machines for manufacturing the components of their requirement	Apply
CO 2	**Apply** surface grinding operations to improve the quality of the surface with desired dimensions by removing uneven spots on the surface	Apply
CO 3	**Analyze** the chip formation mechanism by measuring the cutting forces during the chip formation process	Analyze
CO 4	**Estimate** machining times for machining operations at specified levels of cutting parameters of machine tools	Evaluate
CO 5	**Apply** the principles of limits, fits and tolerance while designing and manufacturing the components of their requirement to get form and position	Apply
CO 6	**Apply** equipment's like Surface Roughness tester, and Tool makers Microscope to find out parameters of gear, thread, tool and surface roughness	Apply

COURSE COURSE KNOWLEDGE COMPETENCY LEVEL:



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises/CIA/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Lab Exercises/CIA/SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	Lab Exercises/CIA/SEE
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	Lab Exercises/CIA/SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2	Lab Exercises/CIA/SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Selection of operations which have to be carried out using machine tools for a specific application, need the knowledge of science and **engineering fundamentals and engineering fundamentals.**	3
	PO 2	**Explain**(Understand) the machining mechanism by measuring the cutting forces during the machining process in developing (complex) desired products by **opportunity identification**, **problem statement**, **model translation**, **solution development and experimentation** using **mathematics and engineering fundamentals**	5
	PO 5	Select, and apply machining operations, resources, and modern **engineering machine tools** including prediction and modeling to complex engineering activities with an understanding of the limitations.	1
	PO 9	Will be **able work** in a **group** with **Maturity**, **independence** and **self direction** to **understand** and **evaluating** work drawings to get the **demonstrated ability** and thereby develop a product after machining using different machine tools	8
CO 2	PO 1	Apply the operational principles of different lathe, milling, drilling machines and various reciprocating machines for quality machining by applying the **knowledge of mathematics, science and engineering fundamentals.**	3
	PO 2	**Explain**(Understand) the machining mechanism by measuring the cutting forces during the machining process in developing (complex) desired products by **opportunity identification**, **problem statement**, **model translation**, **solution development and experimentation** using **mathematics and engineering fundamentals**	5

CO 3	PO 1	Apply the operational principles of different grinding machines for quality machining by applying the **knowledge of mathematics, science and engineering fundamentals.**	3
	PO 2	**Explain**(Understand) the machining mechanism by measuring the cutting forces during the machining process in developing (complex) desired products by **opportunity identification**, **problem statement**, **model translation**, **solution development and experimentation** using **mathematics and engineering fundamentals**	5
	PO 9	Will be **able work** in a **group** with **Maturity**, **independence** and **self direction** to **understand** and **evaluating** work drawings to get the **demonstrated ability** and thereby develop a product after machining using different machine tools	8
CO 4	PO 2	**Explain**(Understand) the machining mechanism by measuring the cutting forces during the machining process in developing (complex) desired products by **opportunity identification**, **problem statement**, **model translation**, **solution development and experimentation** using **mathematics and engineering fundamentals**	5
	PO 9	Design and develop the product manufacturing process effectively as an **individual**, and as a **group member** in **diverse teams, and in multidisciplinary settings** with **Maturity**, **independence** and **self direction** with the **demonstrated ability** for machining effectively in building of product.	8
	PSO 1	Students can apply the knowledge of **Additive manufacturing**, **simulation** and **high speed machining** to implement different machine tools processes for developing a product.	3
CO 5	PO 1	Ability to select and use various Limits and tolerances for proper analysis of design to reach actual conclusion requires some research-based **knowledge of mathematics, science and metrology engineering fundamentals**	3
CO 6	PO 1	Ability to select and use various methods for the measurements of screw threads, surface roughness parameters and the working of optical measuring instruments for proper analysis of results to reach actual conclusion requires some research-based **knowledge of mathematics, science and metrology engineering fundamentals**	3
	PO 9	Design and develop the product manufacturing process effectively as an **individual**, and as a **group member** in **diverse teams, and in multidisciplinary settings** with **Maturity**, **independence** and **self direction** with the **demonstrated ability** for machining effectively in building of product.	8

	PO 12	Students **recognise** the **need for** self-study and importance of **earning skills** in manufacturing technology through **lifelong learning**	3
	PSO 1	Students can apply the knowledge of **Additive manufacturing**, **simulation** and **high speed machining** to implement different machine tools processes for developing a product.	3

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PROGRAM OUTCOMES					PSO'S
	PO 1	PO 2	PO 5	PO 9	PO 12	PSO 1
CO 1	3	2	3	3		
CO 2	3	2				
CO 3	3	2		3		
CO 4		2		3		2
CO 5	3					
CO 6	3			3	2	2

3 = High; 2 = Medium; 1 = Low

XIII ASSESSMENT METHODOLOGY DIRECT:

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

XIV ASSESSMENT METHODOLOGY INDIRECT:

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

XV SYLLABUS:

WEEK 1	**LATHE MACHINE**
	Objective: Perform step turning, taper turning, thread cutting and knurling operations using lathe machine **Solutions Expected:** 1. Adjust the work piece in chuck and single point cutting tool in the tool post with proper alignment. i.e The cutting edge should be set at the same height as the center of work piece 2. Calculate the taper angle and adjust the taper angle by compound rest to perform taper turning operation. Also perform the thread cutting operation at one – fourth speed of spindle by automatic feeding of the tool.
WEEK 2	**DRILLING AND TAPPING OPERATION**
	Objective: Perform the drilling, tapping and step boring using drilling machine **Solutions Expected:** 1. Based on the drawing, perform dot punching on marked location on work piece and accommodate the work piece against drill bit to be done drilling operation 2. Make the holes with standard drill tool then enlarge the hole size in required dimensions by using boring tool. 3. Make the internal thread cutting in that enlarged holes. Required specimen obtained according to specified operaions (drilling and tapping operations)
WEEK 3	**SHAPING**
	Objective: Perform the V-grooving using shaping machine. **Solutions Expected:** 1. Check the groove with the vernier calipers and precision measurement by slip gauges at the end 2. After grooving operation, calculate the stroke length and width of the cut 3. Required specimen will be obtained according to specified operations (shaping operations)

WEEK 4	**SLOTTING**
	Objective: Develop the internal key-ways in the specimen using slotting machine. **Solutions Expected:** 1. Identify and set the proper feed and depth of cut becauge feed should be controlled to avoid any damage to the cutting tool 2. Check the width and depth of keyways with the vernier calipers and precision measurement by slip gauges at the end discs are on the source pole. 3. Required specimen will be obtained according to specified operation (slotting operation)
WEEK 5	**MILLING**
	Objective: Perform the plain milling on the specimen using milling machine. **Solutions Expected:** 1. Identify and set the proper feed and depth of cut because feed should be controlled to avoid any damage to the cutting tool 2. Check the width of specimen with the vernier calipers to perform the machining operation in required size 3. Required specimen will be obtained according to specified operation (milling operations)
WEEK 6	**SURFACE GRINDING**
	Objective: Perform the surface grinding on the rectangular specimen using surface grinding machine **Solutions Expected:** 1. Identify and set the proper feed and depth of cut becauge feed should be controlled to avoid any damage to the cutting tool 2. Check the width of specimen with the micrometer to perform the grinding operation to get in required limits 3. Required specimen will be obtained according to specified limits by grinding operations

WEEK 7	**VERNIER CALIPERS AND MICROMETER**
	Objective: Measure the Length, depth, diameter of given specimen using vernier calipers and micrometer. **Solutions Expected:** 1. Check for zero error when two measuring tip surfaces are in contact with each other, and also check if the surface are not unduly worn out or bent or any dirt collected on them. 2. Set the axis of vernier should be perpendicular to the axis of the object to ensure the correct dimension of the part to measure. 3. Carefully rotate the micro adjustment knurled knob to advance the left jaw to contact the work piece surface edge.
WEEK 8	**SCREW THREAD MEASUREMENT**
	Objective: Measure the Screw thread diameter by three wire method. **Solutions Expected:** 1. Measure the outside diameter of the given thread component by means of outside micrometer, which is equal to major diameter 2. Measure the pitch of the given threaded component by using the pitch gauge 3. Now calculate the pitch or effective diameter as per the formula explained in the theory.
WEEK 9	**SURFACE ROUGHNESS MEASUREMENT**
	Objective: Measure the Surface roughness of specimens by talysurf **Solutions Expected:** 1. Measure the Ra (Roughness Average) rough value of surface which is closely related to the feed and corner radious 2. Examine the deviation between points on a surface and other points on the same surface 3. Measure the surface texture parameters (Roughness, Waviness, Spacing and Hybrid) to control the manufacturing process to the degree required in today's modern world

WEEK 10	**BORE GAUGE**
	Objective: Measure the bore diameter of specimens using bore gauge. **Solutions Expected:** 1. Set the datum point adjustment with a setting ring or master gauge , whose dimension is known accurately 2. DO not disassemble the instrument beyond the needed stage to fit extension rod or change of anvil 3. Calculate the true reading, mean of the reading and standard deviation
WEEK 11	**ANGLE MEASUREMENTS**
	Objective: Tool angle measurements using bevel protractor, sine bar, slip gauges **Solutions Expected:** 1. Do not over tighten main scale knob, keep the overhang of blade as a ruller or screw driver. 2. After doing all the proper adjustment take out the bevel protractor and measure the angle correctly using both the main scale and Vernier scale
WEEK 12	**TAPER MEASUREMENTS**
	Objective: Measure the taper angle of single point cutting tool using Tool Maker's microscope. **Solutions Expected:** 1. Place the tool bit on the glass stage so as to obtain a clear image on which angular measurements are done. 2. Focus the microscope to get a real image super imposed on the graticule pattern of the eye piece 3. Tilt the angle so as to bring the cutting edge of the tool to align with the reference hairline.

TEXTBOOKS

1. R. K. Jain, "Production Technology", Khanna Publishers, 18^{th} Edition, 2013.
2. B. S. Raghu Vamshi, —Workshop Technology Vol – II‖, 9^{th} Edition, Dhanpat Rai Publishers, New Delhi, India. 2010.

REFERENCE BOOKS:

1. B.L. Juneja, G.S. Sekhon, Nitin Seth "Fundamentals of Metal Cutting and Machine Tools ", New Age Publishers, 2^{nd} Edition,2014.
2. Geofrey, "Fundamentals of metal machining and machine tools", Tata McGraw Hill Education, 3^{rd} Edition, 2019.
3. M Mahajan "A Textbook of Metrology ", Dhanpatrai and Co, 2^{nd} Edition, 2013

XVI COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Plain turning, Step turning and Grooving	CO1, CO 2	T1:2.1.5 T2:2.3
2	Step Turning and Taper Turning	CO1,CO 2	T2:2.1.5 R1:2.6
3	Thread cutting and Knurling	CO 2, CO 5, CO 9	T1:2.6 R3:3.6.5
4	Drilling and Tapping	CO 2, CO 5	T2:2.7 R2:2.18
5	Milling Machine	CO 2, CO 9	T2:2.22 R3:3.1.1
6	Surface Grinding	CO 2, CO 4	T1:2.5.1 T2:2.25
7	Shaping Operations	CO 1, CO 12	T2:2.26 R3:2.55
8	Vernier calipers	CO 9	T2:2.3 R3:2.6
9	Inside micrometer	CO 5	T2:2.3 R1:2.6
10	Dial bore indicator	CO 5, CO 9	T1:2.6
11	Spirit level	CO 5, CO 12	T2:2.7 R1:2.18
12	Optical bevel protractor	CO 5, CO 9	T2:2.22
13	Sine bar	CO 5, CO 9	T2:2.25

XVII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Twin vortex formation:** Perform the experimental work with positive zero and negative rake angle for the development of chip mechanism on ductile and brittle material.
2	Optimization of Milling Process parameters for optimal tool life using a Design of Experiments approach.
3	Design and Development of Lathe Machine Cutting Tools Attached with nano Coolant Systems .
4	Design and develop spline hub by using indexing compound mechanism by Slotting Machine.
5	Design and develop of spur gear by universal milling machine.
6	Design and develop a Stir Processing Machine Tool for stir processing on Milling Machine

Prepared by: **HOD, ME**

Dr. K. Ch Apparao, Associate professor

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MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	THEORY OF MACHINES LABORATORY				
Course Code	AMEC26				
Program	B.Tech				
Semester	V	ME			
Course Type	CORE				
Regulation	IARE – UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Ms.V.Lakshmi Prasanna, Assistant Professor				

I COURSE OVERVIEW:

Theory of machines is defined as that branch of engineering science, which deals with the study of relative motion between various parts of a machine and forces which acts on them. The knowledge is very essential for engineer in designing Various parts of a machine.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AMEB11	IV	Materials and Mechanics of Solids	1.5

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Theory of Machines Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Probing Further Experiments (last)	✓	Demo Video	✓	Lab Worksheets	✓	Viva 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-to-day performance and 10 marks for the final internal lab assessment.

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI HOW PROGRAM OUTCOMES ARE ASSESSED:

Program outcomes		**Strength**	**Proficiency Assessed by**
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises/CIA/SEE

PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Lab Exer-cises/CIA/SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exer-cises/CIA/SEE
PO 9	**Individual and team work:**Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Lab Exer-cises/CIA/SEE

3 = High; 2 = Medium; 1 = Low

VII HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

VIII COURSE OBJECTIVES:

The students will try to learn:

I	The Importance of theory of machines and mechanism involved in the day-to-day life, and study of basic mechanisms and inversion mechanisms to form a machine.
II	The information related design and analysis of mechanisms for a specific type of motion in a machine.
III	The developmental use of rigid bodies motions and forces for transmission system, machine kinematics.

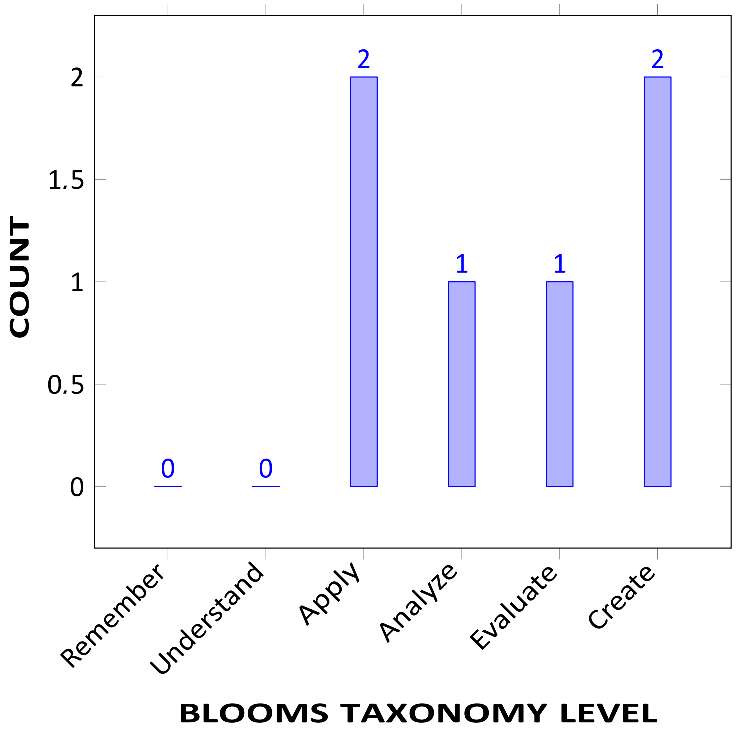
IX COURSE OUTCOMES:

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

CO1	**Identify** the gyroscopic effect for the real time applications of ships, aero planes .	Apply
CO2	**Examine** the life expectancy for ball bearing and their real time application.	Analyze
CO3	**Select** the appropriate journal bearing for balancing of machine components such as shafts.	Apply
CO4	**Build** out the inversion mechanism for 4-bar mechanism to form different mechanical compoenents.	Evaluate

CO5	**Design** the shafts material for calculate the critical speed of shafts	Create
CO6	**Choose** the balancing techniques for effective balancing of machines and structures.	Create

COURSE COURSE KNOWLEDGE COMPETENCY LEVEL:



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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and engineering fundamentals.	2
	PO 2	Understand the given **problem statement and apply data validation techniques to solve** (complex) specific engineering problems related to making of governors	3
CO 2	PO 1	Identify (knowledge) in suitable methods involved during welding for error free components using in solving (complex) engineering problems by applying the principles of **mathematics and engineering fundamentals**	2
	PO 2	Understand the given **problem statement and apply data validation techniques to solve** (complex) specific engineering problems related to welding in identification of process adoption for the specially develop component.	3

CO 3	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals.**	2
	PO 5	Create, select, and apply metal forming techniques, resources, and modern **engineering tools** including prediction and modeling to **complex engineering activities** with an understanding of the limitations.	2
CO 4	PO 1	Recall (knowledge) the basic molding processes uses plastics and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals.**	2
	PSO 3	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 5	PO 1	Identify (knowledge) in suitable methods involved in design, casting to achieve error free components using in solving (complex) engineering problems by applying the principles of **mathematics and engineering fundamentals**	2
	PO 5	Design the ball bearing and estimation of life, and **modern engineering tools** including prediction and modeling to **complex engineering activities** with an understanding of the limitations.	2
	PO 9	Design and develop the journal bearing effectively as an individual, and as a member in **diverse teams, and in multidisciplinary** settings for different lubricant effectively in building of product.	2
CO 6	PO 1	Recall (knowledge) the basic concepts of manufacturing processes and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals** for better solution.	2
	PO 5	Create, select, and apply appropriate mechanisms parameters, resources, and modern **engineering tools** including prediction and modeling to **complex engineering activities** with an understanding of the limitations for effective optimization of prototype / products.	2
	PSO 3	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PROGRAM OUTCOMES				Program Specific Outcomes
	PO 1	PO 2	PO 5	PO 9	PSO 3
CO 1	2	3			
CO 2	2	3			
CO 3	2		2		
CO 4	2				2
CO 5	2		2	2	
CO 6	2		2		2

3 = High; 2 = Medium; 1 = Low

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1, PO 2	SEE Exams	PO 1, PO 2, PO 5, PO 9 PSO 3	Seminars	-
Laboratory Practices	PO 1, PO 2, PO 5, PO 9	Student Viva	PO 1,PO 2, PO 5,PO 9	Certification	-
Assignments	PO 5, PO 9, PO 3	Mini projects	-		

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK 1	**GOVERNOR**
	To study the function of a Governor
WEEK 2	**GYROSCOPE**
	To determine the Gyroscope couple.
WEEK 3	**STATIC FORCE ANALYSIS**
	To draw free body diagram and determine forces under static condition.
WEEK 4	**DYNAMIC FORCE ANALYSIS**
	To draw free body diagram and determine forces under dynamic condition.

WEEK 5	**BALANCING**
	To determine balancing forces and reciprocating masses.
WEEK 6	**JOURNAL BEARING**
	To determine the bearing life.
WEEK 7	**UNIVERSAL VIBRATION**
	To determine the longitudinal and transfer vibration.
WEEK 8	**WHIRLING OF SHAFT**
	To determine critical speed of a shaft.
WEEK 9	**MECHANISMS**
	To design various mechanism and their inversions.
WEEK 10	**DIFFERENTIAL GEAR BOX**
	To study automobile differential gear box.
WEEK 11	**Indexing**
	To study various intermittent mechanism.
WEEK 12	**BEYOND SYLLABUS**
	To study various intermittent mechanism
WEEK 13	**EXAMINATIONS**

TEXTBOOKS

1. Thomas Bevan, "Theory of Machines", Pearson Education, 3rd Edition, 2009.
2. . S.S Ratan, "Theory of Machines", Tata McGraw-Hill, 4th Edition, 2014.

REFERENCE BOOKS:

1. J. S. Rao, R.V. Dukkipati, "Mechanism and Machine Theory", New Age Publication, 1st Edition, 2013.
2. Uiker, Penock, Shigley, "Theory of Machines and Mechanisms", Oxford University Press, 4th Edition, 2013.
3. R.S. Khurmi, Guptha, "Theory of Machines", S.Chand & Co, New Delhi, 14th Edition, 2013.

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Governor	CO1, CO 5	T1:2.1.5 T2:2.3
2	Gyroscope	CO1, CO 5	T2:2.1.5 R1:2.6
3	Static Force Analysis	CO 1, CO 4, CO 5, CO 6	T1:2.6 R3:3.6.5
4	Dynamic Force Analysis	CO 2, CO 6	T2:2.7 R2:2.18
5	Balancing	CO 2, CO 6	T2:2.22 R3:3.1.1

6	Journal Bearing	CO 2, CO 6	T1:2.5.1 T2:2.25
7	Universal Vibration	CO 3, CO 6	T2:2.26 R3:2.55
8	Whirling of Shaft	CO 3, CO 6	T2:2.3 R3:2.6
9	Mechanisms	CO 3, CO 6	T2:2.3 R1:2.6
10	Differential Gear Box	CO 4, CO 6	T1:2.6
11	Indexing	CO 4, CO 6	T2:2.7 R1:2.18

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design of flywheel for I.C engine and punch press.
2	Design of journal bearing using different lubrication oils and different speeds.
3	Design of ball bearing for different loads and estimation of life.
4	Design of differential gear box for automobile I.C Engine.
5	Design of inversion four bar mechanism.

Prepared by: **HOD,ME**

Ms.V.Lakshmi Prasanna,, Assistant professor

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COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**DESIGN FOR MANUFACTURING**				
Course Code	AMEC42				
Program	B.Tech				
Semester	VI				
Course Type	Professional Elective				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	0	0
Course Coordinator	Mr. M.Sunil Kumar, Assitant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC19	V	Machine Tools and Metrology

II COURSE OVERVIEW:

Design for manufacturing is an engineering methodology that focuses on reducing time-to-market and total production costs by prioritizing both the ease of manufacture for the products parts and the simplified assembly of those parts into the final product. The main objective of this course is to design a product for part minimization, quantitative analysis of a design's efficiency, critique product designs for ease of assembly and the importance of involving production engineers in DFMA analysis.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total
Design for Manufacturing	70 Marks	30 Marks	100 Marks

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
16%	Remember
50%	Understand
33%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
	Continuous Internal Examination – 2 (Mid-term)	10	
	AAT-1	5	
	AAT-2	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			100

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

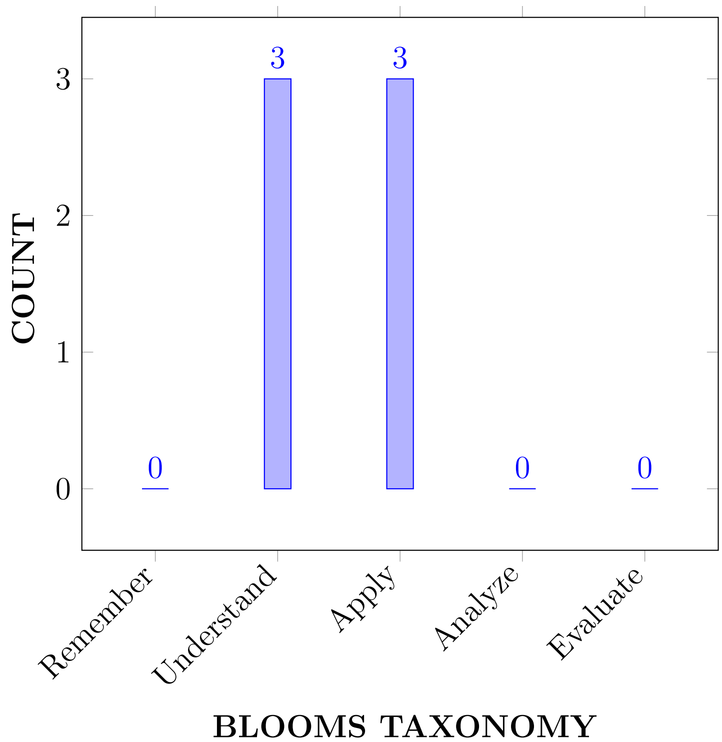
I	The techniques of Design for Manufacture and Assembly (DFMA) is applied for minimizing product cost through design and process improvements.
II	The selection of material and process used in the prototype design in the early stages of product development for cost effectiveness.
III	The Identification of the manufacturing constraints that influence the design of parts and part systems.
IV	The pattern movement in assembly process, assembly errors and minimization steps by considering logical sub-assemblies and re-orientation of parts during machining.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Identify** the concepts of design for manufacturing for product development which minimizes part count in manufacturing process.	Understand
CO 2	**Make use of** the suitable materials for product manufacturing in engineering applications to eliminate expensive and complex features.	Understand
CO 3	**Select** the proper gating and riser system needed for casting requirements to achieve defect/error free components.	Apply
CO 4	**Categorize** various defects and shortcomings during gas welding operation such as TIG, MIG and Spot welding for real time applications.	Understand
CO 5	**Apply** the principles of design for manufacturing processes manual and automated assembly, economical production and material selection.	Apply
CO 6	**Select** the assemble process for assembly transfer systems, Automatic Assembly Transfer Systems and indexing mechanisms for development of assemble process in industries.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Program Outcomes	
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/AAT
PO 12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	CIE/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	3	AAT

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-	✓	✓	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 4	-	-	✓	-		-	-	-	-	-	-	-	✓	-	-
CO 5	-	✓	-	-	-	-	-	-	-	-	-	✓	✓	-	-
CO 6	✓	✓	-	-		-	-	-	-	-	-	-	✓	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall (knowledge) the basic steps involved in robotics and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and physics and engineering fundamentals.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO 1	Recall (knowledge) the basic steps involved in robotics and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and physics and engineering fundamentals.	3
	PO2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design.	5
CO3	PO4	Investigate prototype models based on constraint including Environmental sustainability, Health and safety risks assessment issues and define specific problem.	3
CO4	PO3	Design the solution for problems of voltage doublers and multiplier circuits.	2
CO5	PO2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design.	5
	PSO3	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.	2
CO6	PO 1	Recall (knowledge) the basic steps involved in robotics and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and physics and engineering fundamentals.	3
	PO2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design.	5
	PSO3	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	5	-	-	-	-	-	-	-	-	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	-	-	-	-	-	-	-	-	50	50	-	-
CO 2	100	50	-	-	-	-	-	-	-	-	-	50	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	-	-		50	-	-
CO 4	-	-	20	-		-	-	-	-	-	-	-	50	-	-
CO 5	-	50	-	-	-	-	-	-	-	-	-	50	50	-	-
CO 6	100	50	-	-		-	-	-	-	-	-	-	50	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 -5 $<C \leq 40\%$ – Low/ Slight
2 - 40 % $<C<$ 60% –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	3	3	-	
CO 2	3	2	-	-	-	-	-	-	-	-	-	3	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 4	-	-	2	-	-	-	-	-	-	-	-	-	3	-	-
CO 5	-	2	-	-	-	-	-	-	-	-	-	3	3	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
TOTAL	9	6	5	-	-	-	-	-	-	-	-	9	15	-	-
AVERAGE	3.0	2.0	2.0	-	-	-	-	-	-	3.0	-	-	3.0	-	3.0

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments	✓	Tech Talk	✓		

XVII ASSESSMENT METHODOLOGY-INDIRECT:

X	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	INTRODUCTION TO DFM
	Introduction: Design philosophy, steps in design process, general design rules for manufacture ability, basic principles of designing for economical production, creativity in design; materials: Selection of materials for design, developments in material technology, criteria for material selection, and material selection interrelationship with process selection, process selection charts.
MODULE III	DESIGN FOR MACHINING AND MOULDING
	Machining Process: Overview of various machining processes, general design rules for machining, dimensional tolerance and surface roughness, design for machining ease, redesigning of components for machining ease with suitable examples, general design recommendations for machined parts. Plastics: Viscoelastic and Creep behavior in plastics – Design guidelines for Plastic components – Design considerations for Injection Moulding
MODULE II	DESIGN FOR METAL CASTING AND METAL JOINING
	Metal Casting: Appraisal of various casting processes, selection of casting process, - general design considerations for casting - casting tolerances - use of solidification simulation in casting design - product design rules for sand casting, Metal Joining: Appraisal of various welding processes, Factors in design of weldments - general design guidelines - pre and post treatment of welds - effects of thermal stresses in weld joints - design of brazed joints. Forging - Design factors for Forging - Closed dies forging design - parting lines of dies drop forging die design - general design recommendations. Extrusion and Sheet Metal Work: Design guidelines for extruded sections - design principles for Punching, Blanking, Bending, Deep Drawing - Keeler Goodman Forming Line Diagram - Component Design for Blanking
MODULE IV	DEVELOPMENT OF THE ASSEMBLE PROCESS
	Development of the assemble process, choice of assemble method assemble advantages social effects of automation. Automatic Assembly Transfer Systems: Continuous transfer, intermittent transfer, indexing mechanisms, and operator - paced free – transfer machine
MODULE V	DESIGN OF MANUAL ASSEMBLY
	Design for assembly fits in the design process, general design guidelines for manual assembly, development of the systematic DFA methodology, assembly efficiency, classification system for manual handling, classification system for manual insertion and fastening, effect of part symmetry on handling time, effect of part thickness and size on handling time, effect of weight on handling time, parts requiring two hands for manipulation, effects of combinations of factors, effect of symmetry effect of chamfer design on insertion operations, estimation of insertion time

TEXT BOOKS

1. Geoffrey Boothroyd, "Assembly Automation and Product Design", Marcel and Dekken, Inc., 2nd Edition, 2021.

2. George E. Deiter, "Engineering Design - Material Processing Approach", McGraw Hill Intl. 2nd Edition, 2021.

3. Geoffrey Boothroyd," Hand Book of Product Design", Marcel and Dekken,, N.Y. 2nd Edition, 2021.

REFERENCE BOOKS:

1. Geoffrey Boothroyd, "Hand Book of Product Design", Marcel and Dekken, 1st Edition, 2021
2. Geoffrey Boothroyd, Peter Dewhurst, Winston, "Product Design for Manufacturing and Assembly", CRC Press, 1st Edition, 2021.

WEB REFERENCES:

1. //nptel.ac.in/courses/107103012/
2. //nptel.ac.in/courses/112101005

COURSE WEB PAGE:

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Introduction to Outcome Based Education		
CONTENT DELIVERY (THEORY)			
2	Design philosophy, steps in design process, general design rules for manufacture ability.	CO1	T2: 1.1-1.5, T1: 4.1
3	Basic principles of designing for economical production, creativity in design.	CO1	T2: 1.1-1.5, T1: 4.1
4	Materials: Selection of materials for design, developments in material technology.	CO1	T2: 1.1-1.5, T1: 4.1
5	Criteria for material selection, and material selection interrelationship with process selection.	CO1	T2: 1.1-1.5, T1: 4.1
6	Process selection charts.	CO1	T2: 1.1-1.5, T1: 4.1
7	Machining Process: Overview of various machining processes, general design rules for machining.	CO1	T2: 1.1-1.5, T1: 4.1
8	Dimensional tolerance and surface roughness, design for machining ease	CO1	T2: 1.1-1.5, T1: 4.1
9	Redesigning of components for machining ease with suitable examples, general design recommendations for machined parts	CO1	T2: 1.1-1.5, T1: 4.1
10	Plastics: Viscoelastic and Creep behavior in plastics – Design guidelines for Plastic components.	CO1	T2: 1.1-1.5, T1: 4.1
11	Behavior in plastics, Design guidelines for Plastic components.	CO2	T2: 1.1-1.5, T1: 4.1

12	Metal Casting: Appraisal of various casting processes.	CO2	T2: 1.1-1.5, T1: 4.1
13	Selection of casting process, - general design considerations for casting.	CO2	T2: 1.1-1.5, T1: 4.1
14	Casting tolerances, use of solidification simulation in casting design.	CO2	T2: 1.1-1.5, T1: 4.1
15	Product design rules for sand casting.	CO2	T2: 1.1-1.5, T1: 4.1
16	Appraisal of various welding processes, Factors in design of weldments.	CO2	T2: 1.1-1.5, T1: 4.1
17	General design guidelines - pre and post treatment of welds - effects of thermal stresses in weld joints.	CO2	T2: 1.1-1.5, T1: 4.1
18	Design of brazed joints.	CO2	T2: 1.1-1.5, T1: 4.1
19	Forging, Design factors for Forging, Closed dies forging design.	CO2	T2: 1.1-1.5, T1: 4.1
20	Parting lines of dies drop forging die design, general design recommendations.	CO2	T2: 1.1-1.5, T1: 4.1
21	Design guidelines for extruded sections, design principles for Punching, Blanking, Bending.	CO2	T2: 1.1-1.5, T1: 4.1
22	Deep Drawing, Keeler Goodman Forming Line Diagram, Component Design for Blanking.	CO2	T2: 1.1-1.5, T1: 4.1
23	Development of the assemble process.	CO2	T2: 1.1-1.5, T1: 4.1
24	choice of assemble method assemble advantages.	CO2	T2: 1.1-1.5, T1: 4.1
25	Social effects of automation.	CO3	T2: 1.1-1.5, T1: 4.1
26	Continuous transfer, intermittent transfer, indexing mechanisms, and operator.	CO3	T2: 1.1-1.5, T1: 4.1
27	Paced free, transfer machine	CO3	T2: 1.1-1.5, T1: 4.1

28	Design for assembly fits in the design process.	CO3	T2: 1.1-1.5, T1: 4.1
29	General design guidelines for manual assembly.	CO3	T2: 1.1-1.5, T1: 4.1
30	development of the systematic DFA methodology, assembly efficiency.	CO3	T2: 1.1-1.5, T1: 4.1
31	classification system for manual handling.	CO4	T2: 1.1-1.5, T1: 4.1
32	classification system for manual insertion and fastening.	CO4	T2: 1.1-1.5, T1: 4.1
33	Effect of part symmetry on handling time,	CO5	T2: 1.1-1.5, T1: 4.1
34	Effect of part thickness and size on handling time,	CO5	T2: 1.1-1.5, T1: 4.1
35	Effect of weight on handling time.	CO5	T2: 1.1-1.5, T1: 4.1
36	Parts requiring two hands for manipulation	CO5	T2: 1.1-1.5, T1: 4.1
37	Effects of combinations of factors.	CO6	T2: 1.1-1.5, T1: 4.1
38	Effect of symmetry effect of chamfer design on insertion operations	CO6	T2: 1.1-1.5, T1: 4.1
39	Case study on design of manual assembly.	CO6	T2: 1.1-1.5, T1: 4.1
40	estimation of insertion time.	CO6	T2: 1.1-1.5, T1: 4.1
PROBLEM SOLVING/ CASE STUDIES			
1	Re-Design on Vehicle Front Support Structure Using DFMA.	CO 1	R2:7.5
2	The material of a solid cylindrical tie rod of cross-sectional area “A” and length “L” is to be selected for carrying a tensile load “P” with factor of safety “S”. Explain the process of material selection as per the cost per unit property method.	CO 2	R2:7.5
3	Redesign of Forklift Hydraulic Cylinders using DFMA.	CO 2	R2:7.5
4	Case study in the form design, simple problems in the form design.	CO 2	R2:7.5

5	Selection of Material for an efficient flywheel	CO 2	R2:7.5
6	Selection of material of Spars for man-powered plane	CO 3	R2:7.5
7	Selection of forming of fan for vacuum cleaners	CO 3	R2:7.5
8	Crevice free Tube to Tube sheet welds in Waste Heat Boiler.	CO 3	R2:7.5
9	A batch of 15 cm diameter disks with a thickness of 4 mm are to be molded from acrylonitrile-butadiene-styrene (ABS) in a six-cavity mold. Determine the appropriate machine size.	CO 3	R2:7.5
10	For the 15 cm diameter disks molded in a six-cavity mold, described in Sec. 8.6, the required shot size is 489 cm3 . The recommended injection pressure for ABS is 1000 bars, or 100 MN/m2 . The available power at the injection unit of the 8500kN machine is 90 kW.	CO 4	R2:7.5
11	A sheet metal blank is 200mm long by 150mm wide and has plain semicircular ends with radius 75 mm; It is proposed that 500,000 parts should be manufactured using 16 gauge low carbon steel.	CO 4	R2:7.5
12	A set of only five measuring instruments is to be produced. A DFA analysis shows an estimated assembly time given by TA. Using a 90curve, provide an estimate for the average time to build the first two units. Use this value to determine the average time to assemble the next three units. Assume that the DFA time estimate would apply well for the average assembly time of 100 units	CO 5	R2:7.5
13	Case study on design on lever arch file mechanics.	CO 5	R2:7.5
14	Case study on designing of disposal of valve.	CO 6	R2:7.5
15	Tolerance stack, effects of assembly.	CO 6	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Definitions and Terminology of design for manufacturing.	CO 1	R4:2.1
2	Definitions and Terminology of machining and moulding.	CO 2	R4:2.1
3	Definitions and Terminology of design for metal cutting and metal joining.	CO 3,4	R4:2.1
4	Definitions and Terminology of development of assembly process.	CO 5	R4:2.1
5	Definitions and Terminology of design of manual assembly.	CO 6	R4:2.1
DISCUSSION OF QUESTION BANK			
1	Discussion on question bank of design for manufacturing.	CO 1	R4:2.1
2	Discussion on question bank of machining and moulding.	CO 2	T4:7.3
3	Discussion on question bank of design for metal cutting and metal joining.	CO 3,4	R4:5.1
4	Discussion on question bank of development of assembly process.	CO 5	T1:7.5
5	Discussion on question bank of design of manual assembly.	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,ME**
Mr.M.Sunil Kumar, Assitant Professor

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**Finite Element Methods**				
Course Code	AMEC27				
Program	B.Tech				
Semester	VI	ME			
Course Type	Core				
Regulation	IARE - UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Dr.V.V.S.Haranadh Prasad, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC05	III	Solid Mechanics

II COURSE OVERVIEW:

The finite element analysis (FEA) is a numerical method widely used for modeling and analyzing structures. This course introduces the mathematical modeling concepts of the Finite Element Method for solving structural, thermal and dynamics problems that are too complicated to be solved by analytical methods.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Finite Elements Methods	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
✓	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), and 10 marks for Alternative Assessment Tool (AAT).

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
70%	Understand
20%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
	Continuous Internal Examination – 2 (Mid-term)	10	
	AAT-1	5	
	AAT-2	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			100

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

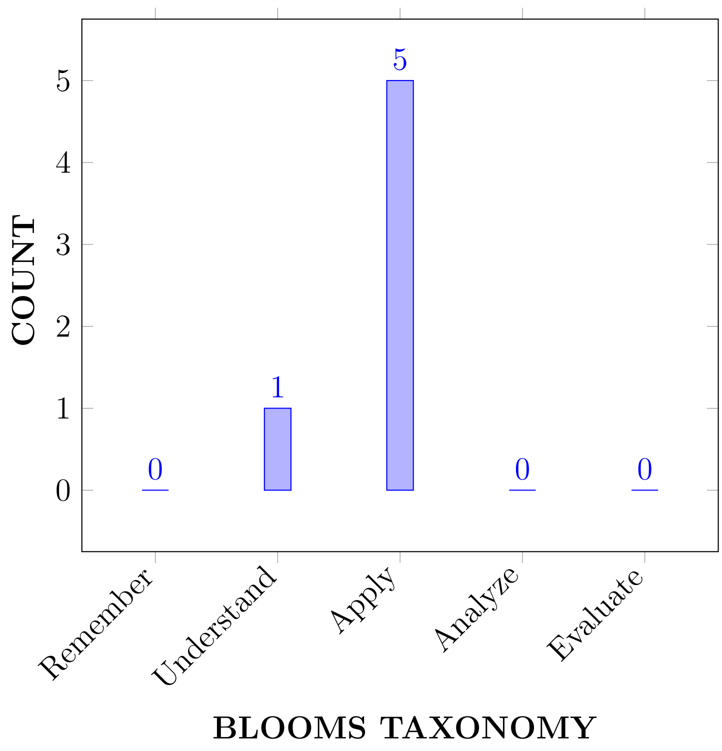
I	The basic concepts of Finite Element methods and its applications to complex engineering problems.
II	The characteristics and selection of different finite elements used in finite element methods.
III	The equilibrium equations and stress-strain relations for different boundary conditions encountered in structural and heat transfer continuum problems.
IV	The application of the FEM technique to dynamic problems and validate the solutions through simulation software for real time applications.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the discretization concepts and shape functions of structural members for computing displacements and stresses.	Understand
CO 2	**Make use of** shape functions of truss and beam elements for obtaining stiffness matrix and load vector to compute nodal displacement, stresses.	Apply
CO 3	**Apply** the discreet models of CST element for estimating displacement and stress.	Apply
CO 4	**Make use of** axi-symmetric modelling concepts to solids of revolution for stress approximation.	Apply
CO 5	**Apply** numerical techniques for heat transfer problems to compute the temperature gradients under various thermal boundary conditions.	Apply
CO 6	**Develop** the governing equations for the dynamic systems to estimate circular frequency and mode shapes, in correlation with modern tools.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:**Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

Program Outcomes	
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/SEE/AAT
PO 2	**Problem Analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/SEE/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	CIE/SEE/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	CIE/SEE/AAT
PO 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	1	CIE/SEE/AAT

PO 12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	CIE/SEE/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	1	Research papers/ Group discussion/ Short term courses
PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	1	Research papers/ Group discussion/ Short term courses

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	-	-
CO 4	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	-	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	✓	-
CO 6	✓	✓	✓	✓-	✓	-	-	-	-	-	-	✓	-	-	✓

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	**Recall engineering knowledge** of potential energy concepts or variational methods for solving complex structural geometries of different fields by using the principles of **mathematics and sciences.**	3

	PO 2	Understand the **problem statement and formulate** stiffness matrix, load vector by using the shape functions.	2
CO 2	PO 1	Apply the **engineering knowledge** of shape functions in truss and beam elements for developing stiffness matrix and load vector by using **principles of mathematics and sciences.**	3
	PO 2	**Identify the problem** of 2D elements and utilize shape functions to **formulate** for obtaining stiffness matrix and load vector for truss and beam elements strains in reaching substantiated conclusions by the **interpretation of results.**	2
	PO 12	Apply the **Personal continuing education efforts** of shape functions in truss and beam elements for developing stiffness matrix and load vector	1
CO 3	PO 1	Identify the **mathematical** model for two dimensional elements for obtaining stiffness matrix and load vector by using principles of **engineering and sciences.**	3
	PO 2	Understand the given **problem and formulate** it by using finite element method to obtain the shape functions of triangular, axi-symmetric and four noded elements.	2
	PO 12	Apply the **Personal continuing education efforts** stiffness matrix and load vector by using principles of engineering and sciences.	1
CO 4	PO 1	Understand the **engineering** concepts of shapes functions to obtain stiffness matrix and load vector for two dimensional elements by using the **principles of mathematics and sciences.**	3
	PO 2	**Identify the problem, formulate** stiffness matrix and load vector for two dimensional elements **for solution development** in reaching substantiated conclusions by the **interpretation of results.**	3
	PO 12	Apply the **Personal continuing education efforts** axisimetric solids and trangular elements.	1
CO 5	PO 1	Illustrate the basics of heat transfer for developing **mathematical models** by using **engineering and sciences.**	3
	PO 2	Recognize the **problem** of heat transfer and formulate thermal stiffness matrix, thermal load vector by applying numerical methods to get the **solution for interpretation of results.**	4
	PO 12	Apply the **Personal continuing education efforts** heat conduction analysis of plates etc.	1
	PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications	1

CO 6	PO 1	Create a model for finding displacements, stresses and strains of structural and thermal problems by using **principles of engineering, sciences and mathematics.**	3
	PO 2	Identify the **problem statement** of different structural and thermal problems and **formulate** it to obtain displacements, stresses and strains for **solving** complex engineering problems in reaching substantiated conclusions by **interpretation of results.**	2
	PO 3	**Use creativity to establish innovative solutions** for dyanmic systems and **Manage the design process and evaluate outcomes**	2
	PO 4	**Identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques** for dynamic system to estimate frequency and mode shapes	2
	PO 5	Make use of **modern tools, create and analyse**mathematical model problems for finding the mechanical and thermal properties of elements.	1
	PO 12	Understand the usage of modern tools like ANSYS, Hyper mesh and NASTRAN to engage in independent and **life-long learning** in the broadest context of **technological change**.	2
	PSO 3	Use of **computational and experimental tools for creating mathematical model** problems in the fields of mechanical, aeronautical and civil.	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE	Program Outcomes/ No. of Key Competencies												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	1	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	1	-	-	-
CO 4	3	3	-	-	-	-	-	-	-	-	-	1	-	-	-
CO 5	3	4	-	-	-	-	-	-	-	-	-	1	-	1	-
CO 6	3	2	2	2	1	-	-	-	-	-	-	2	-	-	1

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	20	-	-	-	-	-	-	-	-	-	12.5	-	-	-
CO 3	100	20	-	-	-	-	-	-	-	-	-	12.5	-	-	-
CO 4	100	30	-	-	-	-	-	-	-	-	-	12.5	-	-	-
CO 5	100	40	-	-	-	-	-	-	-	-	-	12.5	-	50	-
CO 6	100	20	20	18	100	-	-	-	-	-	-	25	-	-	50

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C < 5\%$ – No correlation
1 - $5\ \% \leq C < 40\%$– Low/ Slight
2 - $40\ \% \leq C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	1	-	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	1	-	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	1	-	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	1	-	2	-
CO 6	3	1	1	1	3	-	-	-	-	-	-	1	-	-	2
TOTAL	18	7	1	1	3	-	-	-	-	-	-	5	-	2	2
AVERAGE	3.0	1.1	1	1	3	-	-	-	-	-	-	1	-	2	2

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments	✓	Tech Talk	✓	Projects	✓

XVII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO FEM**
	Introduction to FEM, FEA softwares, Stress–strain and strain-displacement relations for 2D-3D elastic problems,Boundary conditions, One Dimensional problem - Finite element modeling coordinates and shape functions.Assembly of Global stiffness matrix and load vector.
MODULE II	**ANALYSIS OF TRUSSES AND BEAMS**
	Analysis of Trusses - Stiffness matrix for plane Truss Elements, stress calculations and problems; Analysis of beams - Element stiffness matrix for two nodes, two degrees of freedom per node beam element andsimple problems.
MODULE III	**2-D ANALYSIS**
	Finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions, Estimation of load Vector, stresses; Finite element modeling of Axisymmetric solids subjected to Axisymmetric loading with triangular elements. Two dimensional four nodded isoparametric elements.
MODULE IV	**STEADY STATE HEAT TRANSFER ANALYSIS**
	Steady state Heat Transfer Analysis: 1-D Heat conduction of slab 1D fin elements, 2D heat conduction - analysis of thin plates, Analysis of a uniform shaft subjected to torsion.
MODULE V	**DYNAMIC ANALYSIS**
	Dynamic Analysis: Dynamic Analysis - Dynamic equations, formulation of lumped and consistent mass matrices, Eigen Values and Eigen Vectors for a stepped bar, beam; Finite element formulation to 3D problems in stress analysis.

TEXTBOOKS

1. Tirupathi K. Chandrupatla and Ashok D. Belagundu, “Introduction to Finite Elements in Engineering”, Pearson, 4th Edition, 2011.
2. S. Rao, “The Finite Element Methods in Engineering”, Elsevier, 4th Edition 2009.

3. J. N. Reddy, "An Introduction to Finite Element Methods", McGraw Hill, 4th Edition 2009.

REFERENCE BOOKS:

1. O.C. Zienkowitz, "The Finite Element Method in Engineering Science", McGraw Hill. 4th Edition, 2009.
2. Robert Cook, "Concepts and Applications of Finite Element Analysis", Wiley, 4th Edition, 2010.
3. S.Md.Jalaludeen, "Introduction of Finite Element Analysis" Anuradha publications, 4th Edition, 2010

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	OBE Discussion		
CONTENT DELIVERY (THEORY)			
2	Introduction to Finite Element Method for solving field problems, Stress and Equilibrium	CO 1	T1:1.5 R1:2.4
3	Boundary conditions, Stress-strain relations for 2-D and3-D elastic problems, strain displacement relations.	CO 1	T2:2.5 R1:2.5
4	One Dimensional Problem: Finite element modeling coordinates and shape functions	CO 1	T1:2.5 R2:2.6
5	Assembly of Global stiffness matrix and load vector. Finite element equations – Treatment of boundary conditions	CO 1	T1:22.7
6	Quadratic shape functions	CO 1	T2:6.3 R1:5.3
7	Analysis of Trusses: Stiffness matrix for plane Truss Elements	CO 2	T1:6.6 R1:5.3.6
8	Stiffness matrix for plane Truss Elements, stress calculations and problems	CO 2	R3:6
9	Analysis of beams: Element stiffness matrix for two noded, two degrees of freedom per node beam element	CO 2	T1:7.5 R1:6.3
10	Element stiffness matrix for two noded, two degrees of freedom per node beam element	CO 2	T1:8.5 R3:6.8
11	Problems on beams and trusses.	CO 3	T1:12.2 R1:13.1
12	Finite element modeling of two dimensional stress analysis with constant strain triangles	CO 3	T3:12.3 R1:13.2
13	Two dimensional stress analysis with constant strain triangles and treatment of boundary conditions	CO 3	T1:12.10 R1:13.7
14	Estimation of load vector and stresses	CO 3	T1:11.2 R1:10.2

15	Finite element modeling of Axi-symmetric solids subjected to Axi-symmetric loading with triangular Elements	CO 4	T1:11.5 R2:10.3
16	Two dimensional four noded iso parametric elements	CO 4	T1:11.12 R1:11.9
17	Problems on two dimensional elements	CO 4	T1:11.8 R1:11.5
18	Steady state Heat Transfer Analysis: one dimensional analysis of slab	CO 5	T1:9.9
19	Fin and two-dimensional analysis of thin plate Analysis of a uniform shaft subjected to torsion	CO 5	T1:12.1-12.2
20	Dynamic Analysis: Formulation of finite element model	CO 6	T3:11.3 T2:16.13
21	Mass matrices for bar, beam and truss	CO 6	T3:12.3 R1:11.3
22	evaluation of Eigen values and Eigen Vectors for a stepped bar, truss	CO 6	T1:1.5 R1:2.4
23	Finite element-formulation to 3D problems in stress analysis	CO 6	T2:2.5 R1:2.5
24	Finite element-formulation to 3D problems in stress analysis, convergence requirements	CO 6	T1:2.5 R2:2.6
25	Techniques such as semi-automatic and fully automatic use of software such as ANSYS, NISA, NASTRAN	CO 6	T1:22.7
26	Boundary conditions, Stress-strain relations for 2-D and3-D elastic problems, strain displacement relations.	CO 1	T2:2.5 R1:2.5
27	One Dimensional Problem: Finite element modeling coordinates and shape functions	CO 1	T1:2.5 R2:2.6
28	Assembly of Global stiffness matrix and load vector. Finite element equations – Treatment of boundary conditions	CO 1	T1:22.7
29	Quadratic shape functions	CO 1	T2:6.3 R1:5.3
30	Analysis of Trusses: Stiffness matrix for plane Truss Elements	CO 2	T1:6.6 R1:5.3.6
31	Stiffness matrix for plane Truss Elements, stress calculations and problems	CO 2	R3:6
32	Analysis of beams: Element stiffness matrix for two noded, two degrees of freedom per node beam element	CO 2	T1:7.5 R1:6.3
33	Two dimensional four noded iso parametric elements	CO 4	T1:11.12 R1:11.9
34	Problems on two dimensional elements	CO 4	T1:11.8 R1:11.5
35	Steady state Heat Transfer Analysis: one dimensional analysis of slab	CO 5	T1:9.9
36	Fin and two-dimensional analysis of thin plate Analysis of a uniform shaft subjected to torsion	CO 5	T1:12.1-12.2

37	Dynamic Analysis: Formulation of finite element model	CO 6	T3:11.3 T2:16.13
38	Mass matrices for bar	CO 6	T3:12.3 R1:11.3
39	Evaluation of Eigen values and Eigen Vectors for a truss	CO 6	T1:1.5 R1:2.4
40	Finite element-formulation to 1D problems in stress analysis	CO 6	T2:2.5 R1:2.5
PROBLEM SOLVING/ CASE STUDIES			
41	Problems on FEM problems on stress	CO 6	T1:2.5 R2:2.6
42	Problems on FEM problems on equilibrium	CO 6	T1:2.5 R2:2.6
43	Problems on 2-D elastics problems	CO 6	T1:2.5 R2:2.6
44	Problems on 3-D elstic problems	CO 6	T1:2.5 R2:2.6
45	Problems on one dimensional FEM analysis	CO 6	T1:2.5 R2:2.6
46	Problems on two dimensional FEM analysis	CO 6	T1:2.5 R2:2.6
47	Problems on three dimensional FEM analysis	CO 6	T1:2.5 R2:2.6
48	Problems on analysis of beams	CO 6	T1:2.5 R2:2.6
49	Problems on analysis of truss	CO 6	T1:2.5 R2:2.6
50	Problems on element stiffness matrix	CO 6	T1:2.5 R2:2.6
51	Problems on two noded two degree of freedom	CO 6	T1:2.5 R2:2.6
52	Problems on two dimensional stress analysis	CO 6	T1:2.5 R2:2.6
53	Problems on load vector	CO 6	T1:2.5 R2:2.6
54	Problems on load stresses	CO 6	T1:2.5 R2:2.6
55	Problems on steady state heat transfer	CO 6	T1:2.5 R2:2.6
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Introduction to FEM	CO 1	R4:2.1
57	Analysis of Trusses and Beams	CO 2	T4:7.3
58	2-D and 3-D Analysis	CO 3,4	R4:5.1
59	Steady State Heat Transfer Analysis	CO 5	T1:7.5

60	Dynamic Analysis	CO 6	T1: 4.1
DISCUSSION OF QUESTION BANK			
61	Introduction to FEM	CO 1	R4:2.1
62	Analysis of Trusses and Beams	CO 2	T4:7.3
63	2-D and 3-D Analysis	CO 3,4	R4:5.1
64	Steady State Heat Transfer Analysis	CO 5	T1:7.5
65	Dynamic Analysis	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,ME**
Dr.V.V.S.Haranadh Prasad, Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**HEAT TRANSFER**				
Course Code	AMEC29				
Program	B.Tech				
Semester	VI				
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr K. Ch Apparao, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AMEB04	III	Thermodynamics	4
UG	AMEB08	IV	Mechanics of fluids and Hydraulic Machines	4

II COURSE OVERVIEW:

Heat transfer is the flow of thermal energy due to temperature difference and the subsequent temperature distribution changes commonly measured as heat flux. This course focuses on heat transfer modes such as conduction, convection and radiation, boundary conditions, one dimensional steady and unsteady state condition and heat exchangers applied to modern electric and electronic plants require efficient dissipation of thermal losses. Thus there is great relevance for this course in modeling heat exchangers, heat treatment of fins and complex mechanical systems.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Heat Transfer	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
✓	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination..

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question. The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
20%	Understand
70%	Apply
0%	Analyze
0%	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
	Continuous Internal Examination – 2 (Mid-term)	10	
	AAT-1	5	
	AAT-2	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			100

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

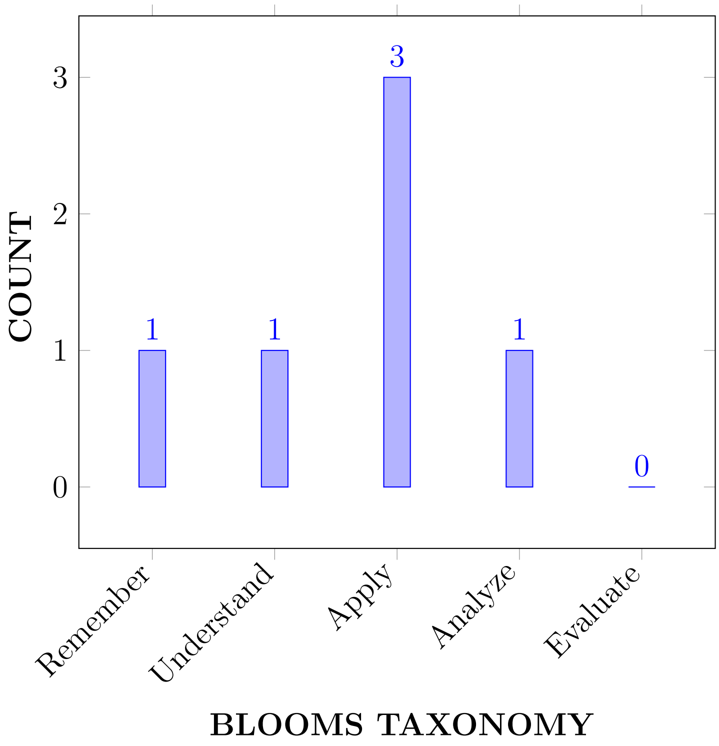
I	The governing equations and performance relations of various modes of heat transfer using the three types of coordinate systems.
II	The concepts for validating heat transfer parameters during internal and external flows based on non-dimensional numbers and convective mode heat transfer.
III	The performance and analysis of heat exchangers for real-time applications using logarithmic mean temperature difference and number of transfer unit methods.
IV	The design methodologies for enhancing heat transfer among a wide variety of practical engineering problems.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Recall** the basic concepts of heat transfer mechanisms and general heat conduction equation in Cartesian, Cylindrical and Spherical Coordinate System for various measures of heat transfer rate.	Remember
CO 2	**Solve** problems involving steady state heat conduction with and without heat generation in simple geometries.	Apply
CO 3	**Make use of** the concept of Boundary layer theory for the derivation of empirical relations related to the characteristics of Boundary layer.	Apply
CO 4	**Utilize** the principles associated with convective heat transfer to formulate and solve the heat transfer coefficients for various cross section areas	Apply
CO 5	**Explain** the physical mechanisms involved in radiation heat transfer, boiling and condensation to give various correlations applied to heat exchangers, boilers, heat engines, etc.	Understand
CO 6	**Analyze** LMTD and NTU techniques for tackling real time problems with thermal analysis, simulation (mathematical model) and cost optimization of heat exchangers	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	SEE/CIA
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	SEE/CIA
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	SEE/CIA
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	SEE/CIA

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	3	SEE/CIA

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	✓	-	-	-	-	-	-	-	-	-	-	✓	-
CO 4	✓	-	✓	-	-	✓	✓	-	-	-	-	-	-	-	
CO 5	✓	-	✓	-	-	-	✓	-	-	-	-	-	-	✓	-
CO 6	-	✓	-	✓	-	✓	✓	-	-	-	-		-	✓	-

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Recall (knowledge) the basic concepts of heat transfer and temperature gradients for various measures of heat transfer rate using **scientific principles** of Methodology, **mathematical principles** and **engineering fundamentals.**	3
CO 2	PO 1	Identify (knowledge) suitable mechanisms for solving the one-dimensional problems with different surfaces and geometries (fins) for which the temperature distribution and heat flow rates are calculated using **mathematical principles** and **engineering fundamentals.**	2
	PO 2	problem analysis based on first **principles of mathematics** and **engineering sciences** is essential to analyze complex engineering problems based on **data collection** which is related to steady state heat conduction with and without heat generation for **validating** the **experimental design solution**	5
CO 3	PO 2	Make use of the concept of Boundary layer theory for the **Design, Model Creation** and **Validation** of **experimental design** of heat transfer geometries by **Problem Analysis**	5

	PO 3	Understand the given **problem statement** related to their working principle and based upon type of **heat transfer process.**	2
	PSO 2	Formulate and evaluate concepts of thermo-fluid systems to **provide solutions** for inter disciplinary **engineering applications** for sustainable designs for new generation heat exchangers, boilers and heat pipes.	2
CO 4	PO 1	Recall (knowledge) the principles associated with convective heat transfer to understand the dynamics of temperature field in fluid flow using **scientific principles** of Methodology, **mathematical principles** and **engineering fundamentals.**	3
	PO 3	Understand the given **problem statement** related to their working principle and based upon type of **heat transfer process.**	2
	PO 6	Gained **Knowledge and understanding** of commercial and economic context of various convection problems will help the students to develop heat transfer equipment which is beneficial for the **society**.	2
	PO 7	Students can develop **socio economic** products in a sustainable manner by understanding the impact of the convection heat transfer solutions in **societal** and **environmental** contexts.	3
CO 5	PO 1	recall (knowledge) the physical mechanisms involved in radiation heat transfer and boiling and condensation phenomena to give various correlations using **mathematical principles** and **engineering fundamentals**.	2
	PO 3	Identify the various properties of boiling and condensation phenomena to heat engines using **Design, analytical** and **mathematical process.**	3
	PO 7	Students can develop **socio economic** products in a sustainable manner by understanding the impact of the radiation heat transfer solutions along with boiling concept in **societal** and **environmental contexts.**	3
	PSO 2	Formulate and evaluate concepts of thermo-fluid systems to **provide solutions** for inter disciplinary **engineering applications** for sustainable designs for new generation heat exchangers, boilers.	2
CO 6	PO 2	Make use of LMTD and NTU techniques used in heat exchangers and fins for the **design, model translation** and **validate** the system and **interpret** the results to get good **experimental design**	5
	PO 4	LMTD and NTU techniques are required to solve problems involving heat transfer rates in heat exchanger and fins based on **experimental data** to **understanding of and ability to apply a systems approach to engineering problems.**	2

	PO 6	**Gained Knowledge** and **understanding** of commercial and economic context of various convection problems will help the students to develop heat exchangers which are beneficial for the **society.**	2
	PO 7	Students can develop **socio economic** products in a sustainable manner by understanding the impact of the heat exchanging solutions in **societal** and **environmental** contexts.	3
	PSO 2	Formulate and evaluate concepts of thermo-fluid systems to **provide solutions** for inter disciplinary **engineering applications** for sustainable designs for new generation heat exchangers, boilers and heat pipes.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE	Program Outcomes/ No. of Key Competencies Matched												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	5	2	-	-	-	-	-	-	-	-	-	-	3	-
CO 4	3	-	2	-	-	2	3	-	-	-	-		-	-	-
CO 5	2	-	3	-	-	-	3	-	-	-	-	-	-	3	-
CO 6	-	5	-	2	-	2	3	-	-	-	-		-	3	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.7	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	50	20	-	-	-	-	-	-	-	-	-	-	100	-
CO 4	100	-	20	-	-	40	66.7	-	-	-	-		-	-	-
CO 5	66.7	-	30	-	-	-	66.7	-	-	-	-	-	-	100	-
CO 6	-	50	-	18.1	-	40	66.7	-	-	-	-		-	100	-

XV COURSE ARTICULATION MATRIX (CO –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
2 - 40 % <C < 60% –Moderate
1-5 <C≤ 40% – Low/ Slight
3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	2	1	-	-	-	-	-	-	-	-	-	-	3	-
CO 4	3	-	1	-	-	2	3	-	-	-	-		-	-	-
CO 5	3	-	1	-	-	-	3	-	-	-	-	-	-	3	-
CO 6	-	2	-	1	-	2	3	-	-	-	-		-	3	-
TOTAL	12	6	3	1	-	4	9	-	-	-	-	-	-	9	-
AVERAGE	3	2	1	1	-	2	3	-	-	-	-	-	-	3	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

X	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO HEAT TRANSFER**
	Modes and mechanisms of heat transfer, basic laws of heat transfer, applications of heat transfer; conduction heat transfer: Fourier rate equation, general three dimensional heat conduction equations in cartesian, cylindrical and spherical coordinates; Simplification and forms of the field equation, steady and unsteady and periodic heat transfer, initial and boundary conditions.
MODULE II	**CONDUCTION HEAT TRANSFER**
	One dimensional steady state conduction heat transfer: Homogeneous slabs, hollow cylinders and spheres, overall heat transfer coefficient, electrical analogy, Critical radius of insulation; one dimensional steady state conduction; heat transfer: with variable thermal conductivity, extended surfaces (Fins) long, short and insulated tips; significance of Biot and Fourier numbers, chart solutions of transient conduction systems.

MODULE III	**CONVECTIVE HEAT TRANSFER**
	Buckingham Pi Theorem and method, application for developing semi, empirical non-dimensional correlation for convection heat transfer, significance of non-dimension numbers, concepts of continuity, momentum and energy equations; free convection: Development of hydrodynamic and thermal boundary layer along a vertical plate, use of empirical relations for vertical plates and pipes. Forced convection: external flows: Concepts of hydrodynamic and thermal boundary layer and use of empirical correlations for convective heat transfer, flat plates and cylinders; Internal flows, Concepts about Hydrodynamic and thermal entry lengths, division of internal flows based on this, use of empirical correlations for horizontal pipe flow and annulus flow
MODULE IV	**RADIATION HEAT TRANSFER**
	Emission characteristics, laws of black-body radiation, Irradiation, total and Monochromatic quantities, laws of Planck, Wien, Kirchhoff, Lambert, Stefan and Boltzmann, heat exchange between two black bodies, concepts of shape factor, emissivity, heat exchange between grey bodies, radiation shields, electrical analogy for radiation networks.
MODULE V	**HEAT EXCHANGERS AND PHASE CHANGE**
	Classification of heat exchangers, overall heat transfer Coefficient and fouling factor, Concepts of LMTD and NTU methods, Problems using LMTD and NTU methods. Boiling: Pool boiling-regimes Calculations on Nucleate boiling, Critical heat flux, Film boiling; Condensation: Film wise and drop wise condensation, Nussels theory of condensation on a vertical plate Film condensation on vertical and horizontal cylinders using empirical correlations.

TEXTBOOKS

1. Yunus A. Cengel, “Heat Transfer A Practical Approach”, Tata McGraw hill Education (P) Ltd, New Delhi, India. 4th Edition, 2012.
2. R. C. Sachdeva, “Fundamentals of Engineering, Heat and Mass Transfer”, New Age, New Delhi, India, 3rd Edition, 2012.

REFERENCE BOOKS:

1. Holman, —Heat Transfer, Tata McGraw-Hill education, 10th Edition, 2011.
2. P. S. Ghoshdastidar, —Heat Transfer, Oxford University Press, 2nd Edition, 2012.

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO’s	Reference T1: 4.1
OBE DISCUSSION			
1	Discussion on OBE to equip the learning skills of students		
CONTENT DELIVERY (THEORY)			
1	Modes and mechanisms of heat transfer, Basic laws of heat transfer	CO 1	T2:2.3
2	Applications of heat transfer	CO 1	R1:2.6

3	Fourier Equation, General heat conduction equations in Cartesian coordinates.	CO 1	T1:2.6
4	General heat conduction equations in Cartesian, Cylindrical and Spherical coordinates.	CO 1	T1:2.6
5	Simplification and forms of the field equation, steady and unsteady and periodic heat transfer.	CO 1	T2:2.7, R1:2.18
6	Transient heat transfer, Initial and boundary conditions	CO 1	T2:2.22
7	One dimensional steady state heat conduction heat transfer Homogeneous slabs,	CO 1	T2:2.25
8	One dimensional steady state heat conduction heat transfer in hollow cylinders	CO 1	T2:2.25
9	One dimensional steady state heat conduction heat transfer in spheres.	CO 2	T2:2.25
10	Overall heat transfer coefficient, Electrical analogy,	CO 1	T2:2.26 R1:2.55
11	One dimensional steady state heat conduction heat transfer:	CO 2	T2:2.16 R1:2.61
12	One dimensional steady state heat conduction heat transfer: systems with variable thermal conductivity	CO 2	T2:2.16 R1:2.61
13	One dimensional steady state heat conduction heat transfer: Systems with internal heat generation.	CO 2	T2:2.16 R1:2.61
14	Extended surfaces (Fins), Long, Short and insulated tips.	CO 2	T2:2.30 R1:2.58
15	Extended surfaces (Fins)	CO 2	T2:2.30 R1:2.58
16	Extended surfaces (Fins), Long and Short	CO 2	T2:2.30 R1:2.58
17	Extended surfaces (Fins) insulated tips.	CO 3	T2:2.30 R1:2.58
18	Systems with negligible internal resistance	CO 3	T2:3.14 R1:4.31
19	Systems with negligible internal resistance, of different geometries.	CO 3	T2:3.14 R1:4.31
20	Significance of Biot and Fourier umbers,	CO 3	T2:3.14 R1:4.33
21	Chart solutions of transient conduction systems.	CO 3	R1:4.36
22	transient conduction systems by Chart solutions of	CO 3	R1:4.36
23	Classification of systems based on causation flow ,condition of flow,	CO 4	T2:3.18 R1:4.64
24	Classification of systems based on causation flow configuration of flow and medium flow	CO 4	T2:3.18 R1:4.64
25	Dimensional analysis as a tool for experimental investigation-Buckingham pi theorem Dimensional	CO 4	T2:3.22 R1:4.67
26	Buckingham pi theorem Dimensional analysis-Application for developing non-dimensional	CO 4	T2:3.22 R1:4.67

27	Dimensional analysis as a tool for experimental investigation-Buckingham pi theorem Dimensional analysis-Application for developing non-dimensional correlation for convective heat transfer.	CO 4	T2:3.22 R1:4.67
28	Concepts of Continuity, Momentum and Energy Equations.	CO 4	T2:3.28 R1:4.67
29	External Flows Concepts of hydrodynamic and thermal boundary layer and use of empirical correlations for Flat plates.	CO 5	T2:4.2 R1:4.67
30	Critical heat flux and film boiling	CO 5	T2:4.3 R1:4.71
31	Development of Hydrodynamic and thermal boundary layer along a vertical	CO 5	T1:4.8 R2:4.68
32	Use of empirical relations for Vertical plates and pipes.	CO 5	T2:4.15 R1:5.74
33	Regimes of Pool boiling and Flow boiling, Critical heat flux, Calculations on Nucleate Boiling	CO 5	T1:4.12 R2:5.75
34	Critical heat flux and film boiling	CO 5	T1:4.8 R2:5.72
35	Condensation, Film wise and drop wise condensation, Nusselts theory of condensation on a vertical plate.	CO 5	T1:5.8 R1:5.73
36	Film condensation on vertical and horizontal cylinders using empirical correlations	CO 5	T1:5.14 R1:6.78
37	Emission characteristics	CO 6	T2:5.19 R1:6.81
38	Black-body radiation, Irradiation, Total and monochromatic quantities, Laws of Planck, Wien, Kirchhoff, Lambert, Stefan and Boltzmann.	CO 6	T1:6.4 R2:6.8
39	Heat exchange between grey bodies.	CO 6	T2:7.7 R1:7.74
40	Concepts of shape factor	CO 6	T1:7.12 R2:8.75
41	Comparison of thermal and non -thermal processes	CO 6	T1:7.8 R1:8.72
42	Radiation shields, electrical analogy for radiation networks.	CO 6	T1:8.8 R3:8.73
43	Classification of heat exchangers	CO 6	T1:9.14 R1:10.78
44	Overall heat transfer Coefficient and fouling factor	CO 6	T2:9.19 R1:10.814
45	Concepts of LMTD and NTU methods	CO 6	T1:10.4 R2:11.68

PROBLEM SOLVING/ CASE STUDIES			
1	The door of a cold storage plant is made from two 6mm thick glass sheets separated by a uniform air-gap of 2mm. The temperature of the air inside the room is -20^0C and the ambient air temperature is 30^0C. Assuming the heat transfer coefficient between glass and air to be 23.26 W/m^2K. Determine the rate of heat leaking in to the room per unit area of the door. Neglect the convection effects in the air-gap. K_{glass} = 0.75WmK ; k_{air} = 0.02W/mK.	CO 1	T2: 1.1-1.5, T1: 4.1
2	A plate 2 cm thick and 10 cm wide is used to heat a fluid at a 30^0C. The heat generation rate inside the plate is 7×10^6 W/m^2. Determine the heat transfer coefficient to maintain the temperature of the plate below 180^0C. Given k (plate) = 26 W/m^0C. Neglect heat losses from the edge of the plate.	CO 1	R1: 1.1-1.5, T2 : 4.1
3	A steel pipe line (k = 50W/mK) of inner diameter (I.D) is 100mm and outer diameter (O.D) is 110mm is to be covered with two layers of Insulation, each having a thickness of 50mm. The thermal conductivity of the first insulation material is 0.06 W/mK and that of the second is 0.12 W/mK. Calculate the loss of heat per metre length of pipe and the interface temperatures between the two layers of insulation when the temperature of the inside tube surface is 250^0C and that of the outside surface of the insulation is 50^0C.	CO 1	T1: 1.1-1.5, T2 : 4.1
4	A standard cast iron pipe (inner diameter = 50 mm and (outer diameter = 55 mm) is insulated with 85 percent magnesium insulation (k = 0.02 W/m^0C). Temperature at the interface between the pipe and insulation is 300^0C. The allowable heat loss through the pipe is 600 W/m length of pipe and for the safety; the temperature of the outside surface of insulation must not exceed 100^0C. Determine i) Minimum thickness of insulation and ii) the temperature inside surface of the pipe assuming its thermal conductivity as 20 W/m^0C.	CO 2	R2: 1.1-1.5, T1: 4.1
6	Estimate the heat loss from a vertical wall exposed to nitrogen at one atmospheric pressure and 4^0C. The wall is 0.2 m high and 2.5 m wide, and is maintained at 56^0C. The average Nusselt number Nu over the height of the plate for natural convection is given by Nu = $0.13(Gr.Pr)^{1/3}$. The properties for nitrogen at a mean film temperature are given as ρ = 1.142 kg/m3, k = 0.026 W/m K, $\nu = 15.63 \times 10^{-6}$ m^2/s, Pr = 0.713.	CO 2	T2: 1.1-1.5, T1: 4.1
7	Estimate the heat transfer coefficient for a laminar fully developed fluid (k=0.175W/mK) inside a 6mm inner diameter tube under uniform wall temperature boundary condition. Also compute heat transfer rate between the tube wall and the fluid for a length of 8m if the mean temp difference between the wall and the fluid is 50^0C.	CO 3	T2: 1.1-1.5, T1: 4.1

8	Two parallel plates 0.5 by 1.0 m are spaced 0.5 m apart. One plate is maintained at 1000^0C and the other at 500^0C. The emissivities of the plates are 0.2 and 0.5, respectively. The plates are located in a very large room, the walls of which are maintained at 27^0C. The plates exchange heat with each other and with the room, but only the plate surfaces facing each other are to be considered in the analysis. Find the net transfer to each plate and to the room.	CO 3	T2: 1.1-1.5, T1: 4.1
9	A glass plate 30 cm square is used to view radiation from a furnace. The transmissivity of the glass is 0.5 from 0.2 to 3.5 μm. The emissivity may be assumed to be 0.3 up to 3.5 m and 0.9 above that. The transmissivity of the glass is zero, except in the range from 0.2 to 3.5μm. Assuming that the furnace is a blackbody at 2000^0C, calculate the energy absorbed in the glass and the energy transmitted.	CO 3	R2: 1.1-1.5, T1: 4.1
10	Water at 10^0C flows over a flat plate (at 90^0C) measuring 1mx1m, with a velocity of 2m/s. properties of water at 50_0C aredensity is 998.1 degree centigrade, ν=0.556x$10^{-6}m^2$/s, Pr=3.54 and k=0.648W/mK. Find: (a) The length of plate over which the flow is laminar, (b) the rate of heat transfer from the entire plate.	CO 4	T2: 1.1-1.5, T1: 4.1
11	Estimate the heat transfer coefficient for a laminar fully developed fluid (k=0.175W/mK) inside a 6mm inner diameter tube under uniform wall temperature boundary condition. Also compute heat transfer rate between the tube wall and the fluid for a length of 8m if the mean temp difference between the wall and the fluid is 50^0C	CO 4	R2: 1.1-1.5, T1: 4.1
12	A black body emits radiation at 2000K. Calculate (i) the monochromatic emissive power at 1 μ.m wavelength,(ii) wavelength at which the emission is maintained and (iii)the maximum emissive power	CO 4	T2: 1.1-1.5, T1: 4.1
13	A glass plate 30 cm square is used to view radiation from a furnace. The transmissivity of the glass is 0.5 from 0.2 to 3.5 μm. The emissivity may be assumed to be 0.3 up to 3.5 m and 0.9 above that. The transmissivity of the glass is zero, except in the range from 0.2 to 3.5μm. Assuming that the furnace is a blackbody at 2000^0C, calculate the energy absorbed in the glass and the energy transmitted	CO 5, CO 6	T2: 1.1-1.5, T1: 4.1
14	A flow of 0.1kg/s of exhaust gases at 700K from a gas turbine is used to preheat the incoming air, which is at the ambient temperature of 300K. It is desired to cool the exhaust to 400K and it is estimated that an overall heat coefficient of 30W/m2K can be achieved in an appropriate exchanger Determine the area required for a counter flow heat exchanger. Take the specific heat of exhaust gasses the same as for air, Which is1000J/kg.K	CO 5, CO 6	R2: 1.1-1.5, T1: 4.1

15	A flow of 0.1kg/s of exhaust gases at 700K from a gas turbine is used to preheat the incoming air, which is at the ambient temperature of 300K. It is desired to cool the exhaust to 400K and it is estimated that an overall heat coefficient of 30W/m2K can be achieved in an appropriate exchanger Determine the area required for a counter flow heat exchanger. Take the specific heat of exhaust gasses the same as for air, Which is1000J/kg.K	CO 5, CO 6	R2: 1.1-1.5, T1: 4.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Conduction, convection and radiation, basic laws of heat transfer (Fouriers Law, Newtons and Law Stefan-Boltzmann law), Conductivity, Emissivity, thermal conductivity, black surface, Steady State process, One –Dimensional Heat Conduction and coordinate system; field equation, steady and unsteady and periodic heat transfer, initial and boundary conditions.	CO 1	R4:2.1
2	One –Dimensional Heat Conduction, critical radius of insulation or critical thickness, fins or Extended surfaces, Fin efficiency and effectiveness, Common applications of finned surfaces, Transient heat conduction, significance of Fourier Number, Periodic heat flow, Heisler charts, Lumped heat analysis, infinite solid, Semi-infinite solids, Biot Number and significance o f Biot number	CO 2	R4:2.1
3	dimensional analysis, importantance of dimensional analysis, Buckingham Pi Theorem, Reynold's number, Nusselt number, Prandtl number, Grashof number, Stanton number, boundary layer thickness, thermal boundary layer, hydrodynamic boundary layer, displacement thickness, forced convection, free or natural convection, boundary layer thickness, significance of boundary layer,	CO 3, CO 4	R4:2.1
4	Stefan-Bolzmann law, Wien's displacement law, Kirchoff's law of radiation, difference between the Stefan Boltzmann law and Wien's law, radiation and irradiation, Lambert's cosine law , concepts of shape factor, emissivity, heat exchange between grey bodies, radiation shields, electrical analogy for radiation networks.	CO 5	R4:2.1
5	heat exchanger, types of heat exchangers, difference between heat exchanger and condenser, open and closed heat exchanger, Recuperators, parallel flow heat exchangers, counter flow heat exchangers, shell and tube heat exchangers, purpose of a shell and tube heat exchanger, LMTD, fouling factor, NTU, effectiveness, Boiling, condensation, nucleate pool boiling, pool boiling, modes of condensation, dropwise condensation, Direct contact condensation and Nucleate boiling.	CO 6	R4:2.1

DISCUSSION OF QUESTION BANK			
1	Modes of Heat Transfer	CO 1	R4:2.1
2	Steady state conduction on slab, cylinder and sphere	CO 2	T4:7.3
3	Boundary layer thickness, numericals on Natural and Forced convection	CO 3,4	R4:5.1
4	Radiation Laws, Emissivity problems with and without shields	CO 5	T1:7.5
5	LMTD, NTU, Boiling and Condensation	CO 6	T1: 4.1

Signature of Course Coordinator **HOD, ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

<table>
<tr><td>Department</td><td colspan="5">MECHANICAL ENGINEERING</td></tr>
<tr><td>Course Title</td><td colspan="5">MACHINE DESIGN</td></tr>
<tr><td>Course Code</td><td colspan="5">AMEC28</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td colspan="5">VI</td></tr>
<tr><td>Course Type</td><td colspan="5">CORE</td></tr>
<tr><td>Regulation</td><td colspan="5">UG-20</td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>3</td><td>1</td><td>4</td><td>-</td><td>-</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Mr. B VijayaKrishna, Assistant Professor.</td></tr>
</table>

I COURSE PRE-REQUISITES:

Level	**Course Code**	**Semester**	**Prerequisites**
B.Tech	AMEC14	IV	Design of Machine Elements
B.Tech	AMEC05	III	Solid Mechanics
B.Tech	AMEC01	II	Engineering Mechanics

II COURSE OVERVIEW:

Machine design emphasizes for safer design practices in the mechanical systems using different theories of failure modes. The Design philosophy is based on strength, stiffness and material selection for manufacture of machine elements. The main objective of this course is to provide rules for the design of general-purpose machine elements such as roller contact and sliding bearings and transmissionsystems, enginepistons etc, which are covered in specialized courses. After the successful completion of the course, the student shall be able to cover all steps of the analysis stage of the design process .

III MARKS DISTRIBUTION:

Subject	**SEE Examination**	**CIE Examination**	**Total Marks**
Machine Design	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), and 10 marks for Alternative Assessment Tool (AAT).

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
30 %	Remember
40 %	Understand
30 %	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		Marks	Total Marks
CIA	Continuous Internal Examination 1 (Mid-term)	10	30
	Continuous Internal Examination 2 (Mid-term)	10	
	AAT-1	5	
	AAT-2	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			100

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

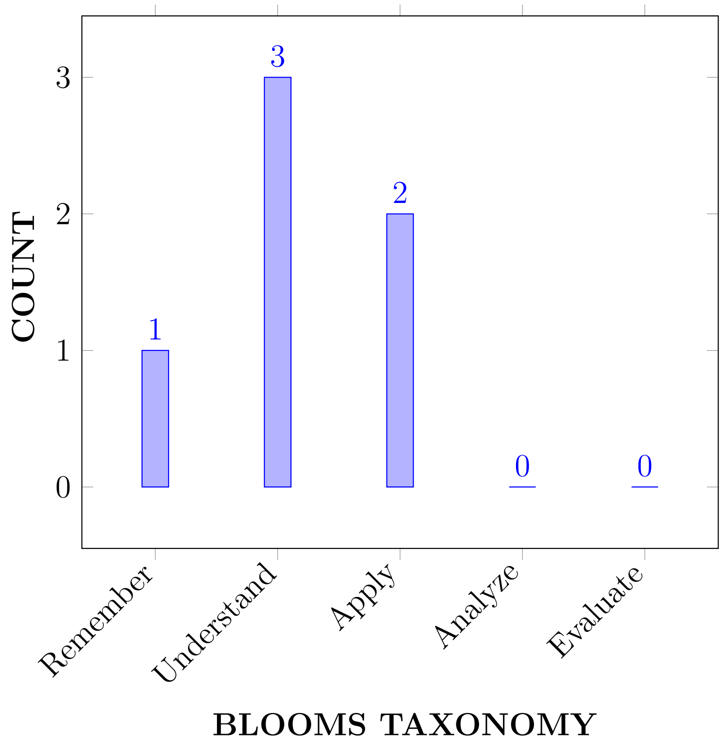
I	To build a system, component, or process that meets desired needs within realistic design constraints for safety, manufacturability and sustainability.
II	To make use of design data hand books to understand the design standards for introducing empirical design data process applicable for mechanical standard elements.
III	To analyze the design parameters for performance evaluation for mechanical transmission elements including bearings, gears and power screw transmission systems.
IV	To elaborate different design criteria and their procedure to carry out the required design steps for application of beam strength criteria for power transmissions in mechanical and allied engineering optimization.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Undesrtand** the lubrication processes of various surface contact bearings and their basic features, terminology and limitations for low speed applications.	Understand
CO 2	**Discuss** the elemental design procedures for various IC engine parts for automobiles applications.	Remember
CO 3	**Apply** the design procedures to calculate the performance of various belt and rope drives for improving transmission efficiencies.	Understand
CO 4	**Implement** process of checking for dynamic and wear considerations for helical,bevel and worm gears.	Apply
CO 5	**Design** of internal combustion engine component by applying the structural and thermal loads to meet the input design specifications using equilibrium equation.	Understand
CO 6	**Identify** the kinematic synthesis for power transmission systems and their scope of application	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

Program Outcomes	
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to ones own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/QUIZ/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/QUIZ/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	CIE/QUIZ/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	CIE/QUIZ/AAT
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	CIE/QUIZ/AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	1	CIE/QUIZ/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	3	Quiz
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	2	Quiz
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies..	2	Quiz

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	✓	-	-	✓	✓	-	-	-	-		✓	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 3	✓	-	-	✓	-	-	-	-	-	-	-	-	-	✓-	-
CO 4	✓	-	-	-		-	-	-	-	-	-		-		✓
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	-	-	-		-	-	-	-	-	-	-	-	-	

XII JUSTIFICATIONS FOR CO PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Develop the various modes of lubrications for bearings by applying the knowledge of mathematics, science and Engineering Fundamentals	3
	PO 3	Develop a relevant static and dynamic load ratings for bearings that meets the specific needs of safety and environmental considerations	2
	PO 6	Extend the theory of friction for metal and non metal materials by contextual knowledge to access safety and the consequent responsibility relevant to professional engineering practices.	1
	PO 7	Understand the impact of lubrication of bearings in extreme conditions for engineering solutions and environmental context for sustainable development.	2
	PSO1	Ability to apply principle of lubrication and load rating for machining of complex design.	1
CO 2	PO 1	Identify the types of loads acting on the connecting rod using the knowledge of mathematics,science and engineering fundamentals for specialised applications in surface treatments.	3
	PSO 1	Develop a resource to identify whipping action of connecting rodg international standards of friction and wear measurements	1
CO 3	PO 1	Make use of various types of belt for power transmission by applying the knowledge of mathematics, science and engineering fundamentals for dynamic conditions of machining.	3
	P0 4	Identify research methods for improving the belt efficiencies to design experiments,analyze and interpretation of results to provide valid conclusions in dynamic lubrication's.	4
	PS0 1	Identify suitable method for application belts during high speed machining condition.	1
CO 4	PO 1	Lists out different types of gears for power transmission by applying knowledge of engineering fundamentals.	1
	PSO 3	Lists out different types of bevel gears by applying knowledge of engineering fundamentals.	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 5	PO 1	Identify the factors thats influence the efficiency of worm gears by the knowledge of engineering fundamentals	1
	P0 2	Relate various factor influencing wear materials to identify ,formulate,complex engineering problems for protection of different materials .	3 .
CO 6	PO 1	Select the various types of power screws by applying the knowledge of science,engineering fundamentals for engineering material selection .	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	2	-	-	1	2	-	-	-	-		1	-	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 3	3	-	-	4	-	-	-	-	-	-	-	-	1	-	-
CO 4	1	-	-	-		-	-	-	-	-	-		-	-	1
CO 5	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	-	-	-	-	-	-	-	-	-	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO PO/ PSO

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - $0 \leq$ C$\leq$ 5% No correlation
1 -5 <C$\leq$ 40% Low/ Slight
2 - 40 % <C < 60% Moderate
3 - 60% $\leq$ C < 100% Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	60	-	-	40	60	-	-	-	-		40	-	-
CO 2	100	-	-	-	-	-	-	-	-	-	-	-	40	-	-
CO 3	100	-	-	-	-	-	-	-	-	-	-	-	40	-	-
CO 4	40	-	-	-		-	-	-	-	-	-		-	-	40
CO 5	40	100	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	60	-	-	-		-	-	-	-	-	-		-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	2	-	-	1	2	-	-	-	-	-	1	-	
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 3	3	-	-	4	-	-	-	-	-	-	-	-	1	-	-
CO 4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
CO 5	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	13	3	2	4	-	1	2	-	-	-	-	-	3	-	-
AVERAGE	2	1	2	3	-	1	2	-	-	-	-	-	1	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

x	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**BEARINGS**
	Types of bearings, basic modes of lubrication, bearing modulus, full and partial bearings, Clearance ratio, Heat dissipation of bearings, bearing materials, Journal bearing design. Ball and roller bearing, Static load-dynamic load, equivalent radial load-design and selection of ball and roller bearings.
MODULE II	**DESIGN OF IC ENGINE PARTS**
	Connecting rod: thrust in connecting rod-stress due to whipping action on connecting rod ends-cranks and crankshafts, forces acting on Piston-construction design and proportions of piston.
MODULE III	**POWER TRANSMISSION SYSTEMS**
	Transmission of power by belt and rope drives, transmission efficiencies, Belts-Flat and V belts .

MODULE IV	**GEARS**
	Spur Gears: Load concentration factor-dynamic load factor, surface compressive strength-bending strength-design analysis of spur gear, check for dynamic and wear considerations. Helical and Bevel Gear: Load concentration factordynamic load factor, Analysis of helicaland bevelgears, check for dynamic and wear considerations. Design of Worm gears: properties of wormgears-selections of materials-strength and wear rating of wormgears-Force analysis-friction in worm gears-thermal Considerations. .
MODULE V	**POWER SCREWS**
	Power screw, design of nut, compound screw, differential screw, ball screw-possible failures.

TEXTBOOKS

1. Richard G. Budynas, J. Keith Nisbett, "Shieglys Mechanical Engineering Design", 10th Edition, 2019.
2. V.B. Bandari, "A Text Book of Design of Machine Elements", 3rd edition, Tata McGraw hill, 2021.

REFERENCE BOOKS:

1. P. Kannaiah, "Machine Design", Scitech Publications India Pvt. Ltd,
2. R.L. Norton, "Machine DesignEdition, New Delhi, 2019. An Integrated approach", Person Publisher, 2 nd
3. U.C. Jindal, "Machine Design", Pearson, 1 st Edition, 2020.
4. R.S. Khurmi, A. K. Gupta, "Machine Design", S. Chand Co, 1 st Edition, 2021. Edition, New Delh i, , 2019
5. J.A.Williams,Engineering Tribology, Oxford Univ. Press, 2018.

WEB REFERENCES:

1. http:www.machine design.com
2. https:ocw.mit.edu/courses/mechanical-engineering/2-810-machine design-fall-2004/index.htm

COURSE WEB PAGE:

Machine Design (UG-20) Akasnsha Learning Management System B.Vijaya krishna

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on outcome Based Education (OBE) : Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	CO1,2,3,4,5,6	
CONTENT DELIVERY (THEORY)			
2	Types of journal bearings	C01	T1: 1.2-1.4, T1: 4.1
3	Basic modes of lubrication	C01	T2: 1.1-1.5, T1: 4.1
4	Heat dissipation of bearings, bearing materials, Journal bearing design	C01	T1: 1.8-1.9, T1: 4.1
5	Bearing materials, Journal bearing design	C01	T2: 2.3-2.7, T1: 4.1
6	Ball and roller bearing, Static load-dynamic load	C01	T2: 3.6-3.7, T1: 4.1
7	Equivalent radial load-design and selection of ball and roller bearings.	C01	T2: 2.1-2.5, T1: 3.1
8	Thrust in connecting rod	C02	T2: 4.1-4.5, T1: 2.1
9	Crankshafts	C02	T2: 3.1-3.5, T1: 5.1
10	forces acting on Piston-construction design and proportions of piston	C02	T2: 1.1-1.5, T1: 4.2
11	Theoretical wear models	C02	T2: 4.1-4.5, T1: 4.3
12	Belts Drives	C03	T2: 1.1-1.5, T1: 4.8
13	Rope Drives	C03	T2: 1.1-1.7, T1: 5.1
14	Chain Drives	C03	T2: 1.1-1.8, T1: 5.9
15	V-belt drives	C03	T2: 1.6-1.9, T1: 3.1
16	Load concentration factor-dynamic load factor,	C03	T2: 2.1-.5, T1: 5.1
17	surface compressive strength-bending strength	C04	T2: 1.3-1.5, T1: 4.1

18	Design analysis of spur gear	C04	T2: 1.4-1.5, T1: 3.1
19	Check for dynamic and wear considerations	C04	T2: 4.1-4.5, T1: 2.1
20	Helical and Bevel Gear: Load concentration factor	C04	T2: 1.1-1.5, T1: 6.1
21	Dynamic load factor, Analysis of helicaland bevelgears	C04	T2: 3.8-3.9, T1: 3.1
22	check for dynamic and wear considerations	C04	T2: 7.1-7.5, T1: 9.1
23	Design of Worm gears: properties of wormgears,	C04	T2: 6.1-6.5, T1: 5.1
24	Selections of materials	C04	T2: 9.1-5.5, T1: 8.1
25	Strength a of wormgears	C04	T2: 4.3-4.9, T1: 2.1
26	Srating of wormgears	C04	T2: 10.1-10.5, T1: 10.1
27	Hydro static lubrication.	C04	T2: 10.1-10.5, T1: 4.1
28	Principle of Threads	C05	T2: 1.1-1.5, T1: 40.1
29	Classification of Threads	C05	T2: 10.1-10.5, T1: 4.1
30	Types of Threads	C05	T2: 9.1-9.5, T1: 9.1
31	Factors influencing Threads	C05	T2: 8.1-8.5, T1: 4.3
32	Testing of Threads	C05	T2: 4.1-4.5, T1: 2.2
33	Evaluation of Threads	C05	T2: 1.1-1.5, T1: 4.4
34	Prevention of Threads	C05	T2: 1.1-1.5, T1: 4.9
35	Material selection,	C06	T2: 7.1-7.5, T1: 6.1
36	Power screws	C06	T2: 2.1-2.5, T1: 5.1
37	lead screws	C06	T2: 5.1-5.5, T1: 4.1
38	Design of nuts	C06	T2: 6.1-6.5, T1: 4.1
39	Nut Materials	C06	T2: 1.1-1.5, T1: 4.1

40	Applications of nuts	C06	T2: 1.1-1.5, T1: 4.1
PROBLEM SOLVING/ CASE STUDIES			
1	Sliding bearins	CO1	R1:7.7
2	Modes of Lubrications	CO2	R2:6.5
3	Thermal considerations in sliding contact	CO2	R2:7.8
4	Connecting Rod Design	CO3	R1:4.5
5	Cranskhsaft Design	CO3	R2:7.5
6	International standards in Piston design	CO3	R2:5.5
7	Belt Drives	CO4	R2:3.5
8	Rope Drives	CO4	R2:1.5
9	V-Belt Drive	CO4	R2:6.1
10	Spur Gears	CO4	R2:1.5
11	Worm Gever	CO5	R2:7.1
12	Bevel Gear	CO5	R2:1.23
13	Power Screw	CO6	R2:8.3
14	Design of nut	CO6	R2:8.8
15	Design of screw	CO6	R2:8.9
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Rolling Bearing	CO1,CO2	R1:2.1
2	IC Engine Parts	CO3	R1:2.1
3	Gears	CO4	R2:2.1
4	Power Screws	CO5	R4:2.1
5	Transmissions systems	CO6	R2:5.4
DISCUSSION OF QUESTION BANK			
1	Module I: Bearings	CO1,CO2	R2:4.1
2	Module II: IC Engine Parts	CO 3	T4:7.3
3	Module III:Power transmission systems	CO4	R4:5.1
4	Module IV: Gear	CO5	T1:7.5
5	Module V: Power Screws	CO6	T1: 4.1

Signature of Course Coordinator **HOD,ME**
Mr.B.Vijayakrishna , Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**ROBOTICS**				
Course Code	**AMEC32**				
Program	**B.Tech**				
Semester	**VI**				
Course Type	**Professional Elective-II**				
Regulation	**UG-20**				
Course Structure	**Theory**			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	0	0
Course Coordinator	Dr. S Sathees Kumar, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC10	IV	Kinematics of Machinery
B.Tech	AMEC18	V	Dynamics of Machinery

II COURSE OVERVIEW:

Robotics is recognised as one of the important aids of mechatronics systems and provides applications in the unmanned areas of industrial automation. This course is an introduction to the field of robotics and covers the fundamentals of kinematics, dynamics, , trajectory planning. The course deals with homogeneous transformations, forward and inverse kinematics of robotic manipulators, differential kinematic equations, the manipulator Jacobian, and Euler formulations. Its also focuses the actuators and sensors are used in the robots.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total
Robotics	70 Marks	30 Marks	100 Marks

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), and 10 marks for Alternative Assessment Tool (AAT).

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
66.66%	Understand
33.34%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
	Continuous Internal Examination – 2 (Mid-term)	10	
	AAT-1	5	
	AAT-2	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			100

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

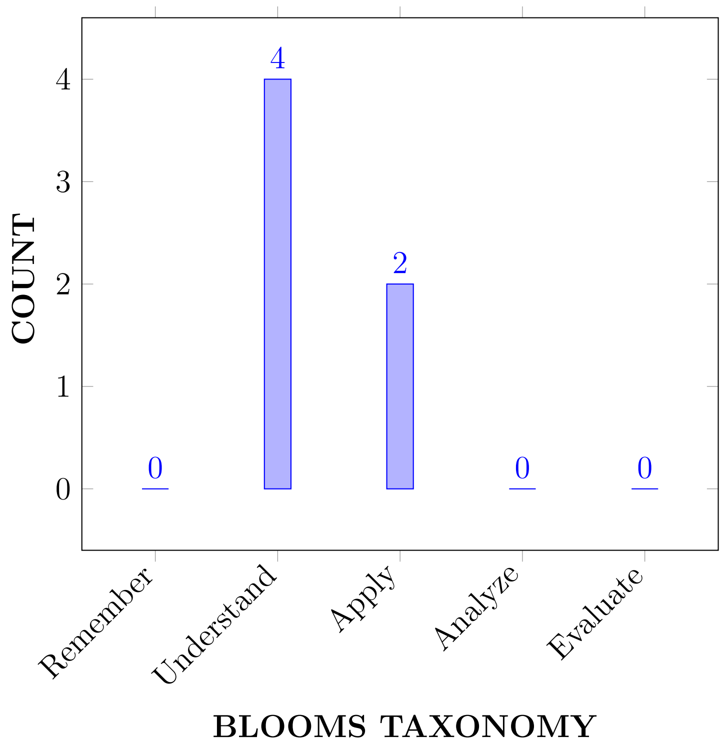
I	The fundamental concepts of various configurations of the robot manipulators and their working principles used in the industries.
II	The basics of motion analysis of manipulator and process to find forward kinematics and inverse kinematics of the robot manipulator
III	The path planning of a robot manipulator for given polynomial equation and how to avoid obstacles in its path.
IV	The performance of various feedback components like sensors and actuators and how they can be used according to the specifications of the manipulator.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Outline** the relationship between mechanical structures of industrial robots and their operational workspace characteristics.	Understand
CO 2	**Develop** the mechanism for solving forward and inverse kinematics of simple robot manipulators.	Apply
CO 3	**Construct** a capability for obtaining the Jacobian matrix and using it to identify singularities.	Apply
CO 4	**Explain** an ability to generate the trajectory for given application of robot manipulator.	Understand
CO 5	**Interpret** the various actuators and sensors used in the robots based on their applications.	Understand
CO 6	**Outline** the functioning of numerious robots in material handling, welding, assembly and inspections.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations

Program Outcomes	
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	CIE/Quiz/AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	CIE/Quiz/AAT
PO 12	**Life long learning:** the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	3	Quiz
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications	1	Quiz
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	1	Quiz

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-	✓	✓	-	✓
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	✓	-		-	-	-	-	-	-		-	-	-
CO 5	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	✓
CO 6	✓	✓	-	-		-	-	-	-	-	-	✓	-	-	✓

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall (knowledge) the basic steps involved in robotics and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and physics and engineering fundamentals.	3
	PO12	Understanding the applications of robots is helpful in the broadest context of technological change	1
	PSO1	Utilize ideation to enhance the product development towards digital manufacturing	1
	PSO3	Ability to explain and demonstrate the various applications of robots for research and career enhancement.	1
CO 2	PO 1	Recall (knowledge) the basic steps involved in robotics and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and physics and engineering fundamentals.	3
	PO2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design.	5
CO3	PO4	Investigate prototype models based on constraint including Environmental sustainability, Health and safety risks assessment issues and define specific problem.	3
CO4	PO3	Design the solution for problems of voltage doublers and multiplier circuits.	2
CO5	PO2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design.	5
	PSO3	Ability to explain and demonstrate the various sensors and actutors in robots for research and development	1
CO6	PO 1	Recall (knowledge) the basic steps involved in robotics and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and physics and engineering fundamentals.	3
	PO2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design.	5
	PO12	Understanding the applications of robots is helpful in the broadest context of technological change	1
	PSO3	Ability to explain and demonstrate the various robots used in manufacturing fields for product development	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	2	2	-	2
CO 2	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	2	-	-	-	-	-	-	-	-		-	-	-
CO 5	-	5	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 6	3	5	-	-	-	-	-	-	-	-	-	2	-	-	2

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	-	-	-	-	-	-	-	-	25	100	-	100
CO 2	100	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	27	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	20	-		-	-	-	-	-	-		-	-	-
CO 5	-	50	-	-	-	-	-	-	-	-	-	-	-	-	100
CO 6	100	50	-	-		-	-	-	-	-	-	25	-	-	100

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	1	3	-	3
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	2	-	-	-	-	-	-	-	-	-	-	-	-	3
CO 6	3	2	-	-	-	-	-	-	-	-	-	1	-	-	3
TOTAL	9	6	1	1	-	-	-	-	-	-	-	2	3	-	9
AVERAGE	3.0	2.0	1.0	1.0	-	-	-	-	-	-	-	1.0	1.0	-	3.0

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments		Tech Talk	✓		

XVII ASSESSMENT METHODOLOGY-INDIRECT:

X	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION AND COMPONENTS OF THE INDUSTRIAL ROBOTICS**
	Introduction: Automation and Robotics, CAD/CAM and Robotics – An over view of Robotics – present and future applications. Components of the Industrial Robotics: common types of arms. Components, Architecture, number of degrees of freedom – Requirements and challenges of end effectors, Design of end effectors, Precision of Movement: Resolution, Accuracy and Repeatability, Speed of Response and Load Carrying Capacity.
MODULE II	**MOTION ANALYSIS**
	Motion Analysis: Basic Rotation Matrices, Equivalent Axis and Angle, Euler Angles, Composite Rotation Matrices. Homogeneous transformations as applicable to rotation and translation – problems. Manipulator Kinematics-H notation-H method of Assignment of frames-H Transformation Matrix, joint coordinates and world coordinates, Forward and inverse kinematics – problems on Industrial Robotic Manipulation.
MODULE III	**TRAJECTORY PLANNING**
	Differential transformation of manipulators, Jacobians – problems. Dynamics: Lagrange – Euler and Newton – Euler formations – Problems. Trajectory planning and avoidance of obstacles, path planning, Slew motion, joint interpolated motion – straight line motion.
MODULE IV	**ROBOT ACTUATORS AND FEEDBACK COMPONENTS**
	Robot actuators and Feedback components: Actuators: Pneumatic, Hydraulic actuators, electric and stepper motors, comparison of Actuators, Feedback components: position sensors – potentiometers, resolvers, encoders – Velocity sensors, Tactile and Range sensors, Force and Torque sensors.
MODULE V	**ROBOT APPLICATION IN MANUFACTURING**
	Material Transfer - Material handling, loading and unloading- Processing - spot and continuous arc welding and spray painting - Assembly and Inspection

TEXTBOOKS

1. Groover M P, “Industrial Robotics”, Mc Graw Hill
2. Ramachandran Nagarajan, “Introduction to Industrial Robotics”, Pearson,

REFERENCE BOOKS:

1. Spony, Vidyasagar, “Robot Dynamics and Controls”, John Wiley
2. Asada, Slotine, ”Robot Analysis and control”, Wiley Inter-Science

WEB REFERENCES:

1. http://nptel.ac.in/courses/112101099
2. http://www.intechopen.com/books/robot-control
3. http://www.som.com

COURSE WEB PAGE:

Robotics (UG-20) Akasnsha Learning Management System

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO’s	Reference
OBE DISCUSSION			
1	Introduction to Outcome Based Education		
CONTENT DELIVERY (THEORY)			
2	Introduction to robotics and automation, an over view of robotics – Prerequisites.	CO1	T1: 41
3	An over view of Robotics	CO1	T1: 42
4	Components of the Industrial Robotics: common types of arms.	CO1	T1:42, T2: 2.1
5	Requirements and challenges of end effectors	CO1	T1:43
6	Design of end effectors	CO1	T1:46
7	Precision of Movement - Resolution and Accuracy .	CO1	T1:48
8	and Repeatability and Speed of Response	CO1	T1:49
9	Load Carrying Capacity	CO1	T1:51
10	Present and future applications of robots.	CO1	T1:52
11	Motion Analysis: Basic Rotation Matrices	CO2	T1:54
12	Equivalent Axis and Angle and Euler Angles	CO2	T1:56
13	Composite Rotation Matrices	CO2	T1:57
14	AHomogeneous transformations as applicable to rotation and translation	CO2	T1:59
15	Manipulator Kinematics-H notation-H method of Assignment of frames	CO2	T2: 1.1-1.4
16	Robot Kinematics	CO2	T2: 1.1-1.5
17	H Transformation Matrix	CO2	T2: 1.1-1.7
18	joint coordinates and world coordinates	CO2	T2: 1.1-1.8
19	Forward and inverse kinematics	CO2	T2: 1.1-1.5
20	Problems on Industrial Robotic Manipulation	CO2	T2: 1.1-1.10

21	Differential transformation of manipulators	CO3	T2: 1.1-1.12
22	Jacobians – problems.	CO3	T2: 1.1-1.14
23	Dynamics: Lagrange equationa	CO3	T2: 1.1-1.16
24	Euler and Newton Problems.	CO3	T2: 1.1-1.19
25	Euler formations – Problems	CO3	T2: 2.1-1.5
26	Trajectory planning	CO4	T2: 1.2-2.2
27	Avoidance of obstacles	CO4	T2: 2.1-2.2
28	Path planning and Slew motion,	CO4	T2: 1.2-2.9
29	Joint interpolated motion	CO4	T2: 2.1-2.5
30	Straight line motion and Problems	CO4	T2: 2.1-2.6
31	Robot actuators	CO4	T2: 1.1-2.9 T1: 4.1
32	Feedback components: Actuators	CO4	T2: 2.1-2.10
33	: Pneumatic and Hydraulic actuators	CO5	T2: 1.1-1.5
34	Electric and stepper motors	CO5	T2: 2.1-2.13,
35	Comparison of Actuators	CO5	T2: 2.1-2.15, T1: 4.1
36	Feedback components: position sensors – potentiometers	CO5	T2: 2.1-17, T1: 4.1
37	Resolvers and encoders	CO5	T1:92
38	Velocity sensors, Tactile and Range sensors	CO5	T1:94
39	Working of a Velocity sensors	CO5	T1:96
40	Working of a , Force and Torque sensors.	CO5	T1:97
41	Material handling	CO6	T2: 3.1-3.5
42	Material Loading and unloading	CO6	T2: 3.1-3.9
43	Materials Processing -	CO6	T2: 4.1-4.7
44	Spot and continuous arc welding	CO6	T2: 4.1-4.9

45	Spray painting	CO6	T2: 4.1-4.9
46	Assembly and Inspection,	CO6	T2: 4.1-4.11
PROBLEM SOLVING/ CASE STUDIES			
1	Numerical Examples working of resolvers and optical encoder	CO 1	R2:7.5
2	Numerical examples on Homogeneous transformation matrix in robot kinematics	CO 2	R2:7.5
3	Numerical examples on H-transformation matrix in robot kinematics	CO 2	R2:7.5
4	Numerical examples on rotation matrix in robot kinematics	CO 2	R2:7.5
5	Numerical examples on transklation matrix in robot kinematics	CO 2	R2:7.5
6	Solving the Kinematic Equations using transformation robotics	CO 3	R2:7.5
7	Solving the Kinematic Equations (forward and reverse) using transformation robotics	CO 3	R2:7.5
8	Solving the Jacobian matrix to find the motion analysis of an arm	CO 3	R2:7.5
9	Solving the Lagrange equations to find the motion analysis of an arm	CO 3	R2:7.5
10	Solving the Euler and Newton equation to find the motion analysis of an arm	CO 4	R2:7.5
11	Solving the Euler formations to find the motion analysis of an arm	CO 4	R2:7.5
12	Problems on slew motions	CO 5	R2:7.5
13	Problems on joint interpolated motion motions	CO 5	R2:7.5
14	Problems on straight line motions	CO 6	R2:7.5
15	Problems on slew motions	CO 6	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Definitions and Terminology of robotics and automation.	CO 1	R4:2.1
2	Definitions and Terminology of motion analysis of robots.	CO 2	R4:2.1
3	Definitions and Terminology of differential kinematics and trajectory planning	CO 3,4	R4:2.1
4	Definitions and Terminology of Actuators and Sensors	CO 5	R4:2.1
5	Definitions and Terminology of robots used in Manufacturing	CO 6	R4:2.1

DISCUSSION OF QUESTION BANK			
1	Discussion on question bank of robotics and automation	CO 1	R4:2.1
2	Discussion on question bank of motion analysis of robots	CO 2	T4:7.3
3	Discussion on question bank of differential kinematics and trajectory planning	CO 3,4	R4:5.1
4	Definitions and Terminology of Actuators and Sensors	CO 5	T1:7.5
5	Discussion on question bank of robots used in Manufacturing	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,ME**
Dr.S.Sathees Kumar, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEEERING

COURSE DESCRIPTION

Course Title	DISASTER MANAGEMENT					
Course Code	ACEC31					
Program	B.Tech					
Semester	VI					
Course Type	Open Elective					
Regulation	IARE-UG20					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	3	-	3	-	-	
Course Coordinator	Ms. Patnala V S Neelima, Assistant Professor					

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	-	-	-

II COURSE OVERVIEW:

The Disaster management provides a fundamental understanding of different aspects. It deals with the concepts and functions of disaster management to build competencies of professionals and development practitioners. It provides effective supporting environment by the governmental locating substantial resources for effective mitigation of disasters. It helps learners to apply the disaster mitigation strategies, preparedness for reducing damage intensity, loss of life and property.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Disaster Management	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1.

Percentage of Cognitive Level	Blooms Taxonomy Level
17%	Remember
83 %	Understand
0%	Apply
0 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
	Continuous Internal Examination – 2 (Mid-term)	10	
	AAT-1	5	
	AAT-2	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			100

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. **Alternative Assessment Tool (AAT)**

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	**Tech-talk**	**Complex Problem Solving**
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

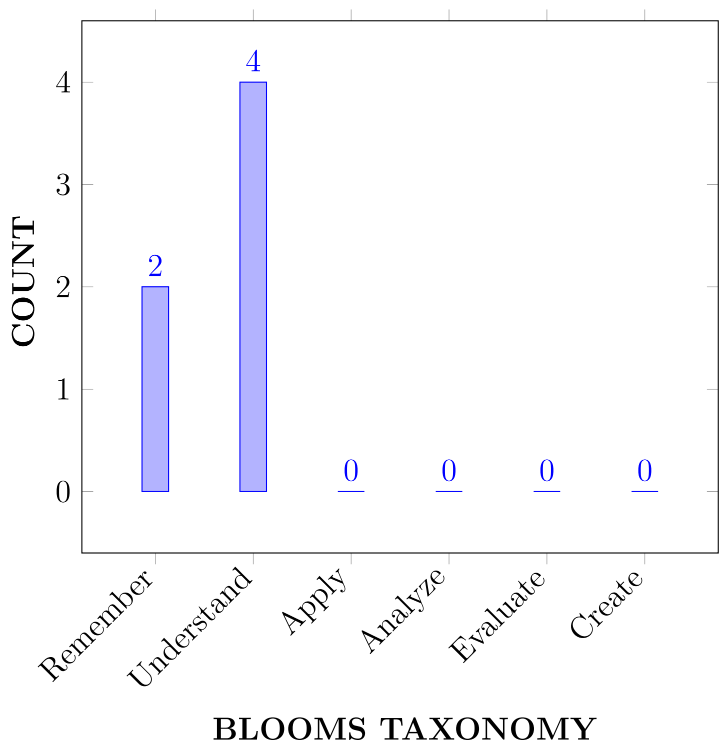
I	The concept of environmental hazards, disasters and various approaches dealing with the mitigation of disasters.
II	The knowledge on various types of environmental disasters and their impacts on human beings and nature.
III	The Different types of endogenous and exogenous hazards and their influence on human life and nature.
IV	The immediate response and damage assessment with information reporting and monitoring tools.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Classify** Environmental hazards for developing modern disaster management system.	Remember
CO 2	**Illustrate** various approches for reducing the level of risk associated with Disasters.	Understand
CO 3	**Compare** natural and manmade disasters for finding out intensity of damage loss occurred by them.	Understand
CO 4	**List** various hazards and their effects for evaluating their impact on society and Environment.	Remember
CO 5	**Outline** human adjustments and perception towards hazards for mitigation of disasters.	Understand
CO 6	**Summarize** disaster phenomenon and its different contextual aspects for implementing the Disaster Risk Reduction Strategy.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/SEE/AAT
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	3	CIE/SEE/AAT
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	3	CIE/SEE/AAT
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	1	CIE/SEE/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Build skills to develop software applications in specialized areas of Computer Science and Engineering such as Artificial Intelligence, Machine Learning, Data Science, Web Development, Gaming, Augmented Reality / Virtual Reality (AR/VR).	-	-
PSO 2	Focus on exploring supervised, unsupervised and reinforcement learning and apply them to a range of AI problems.	-	-
PSO 3	Make use of AI and ML techniques for industrial applications in the areas of Autonomous Systems, IOT, Cloud Computing, Robotics, Natural Language Processing and emerging areas.	-	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 2	✓	-	-	-	-	✓	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	✓	✓	-	-	-	-	-	-	-	-
CO 4	-	-	-	-	-	✓	✓	-	-	-	-	-	-	-	-
CO 5	✓	-	-	-	-	✓	-	-	-	-	-	-	-	-	-
CO 6	✓	-	-	-	-	✓	-	-	✓	-	-	-	-	-	-

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the knowledge and principals of mathematics to engineering problems in determining an area enclosed by irregular boundary line using the knowledge of **mathematics and science fundamentals**	2
	PO 7	Understand the disaster management by considering Environmental impacts on the livelihood and their effect on Socio economic issues for sustainable development.	2
CO 2	PO 1	Apply the knowledge on various disaster mitigation approaches in **engineering disciplines** and and use their application in geographical researches.	1
	PO 6	Apply the engineering knowledge in disaster management to **promote sustainable development** and build **Awareness on health, safety,** and **risk issues** associated with Disasters.	4
CO 3	PO 6	Identify **engineering activities including personnel, health, safety, and risk and effective disaster management strategies** for implementing, analyzing disaster impacts on human life and environment.	4
	PO 7	Understand intensity of disasters and their impact on **environment** and influence on **socio economic** parameter for assessment of intensity of risk.	2
CO 4	PO 6	Identify **engineering activities including personnel, health, safety, and risk** for analyzing hazard impacts on environment.	4
	PO 7	Identify the impact of various hazards in **socio economic and environmental** aspects for developing modern disaster management system.	2

CO 5	PO 1	Understand the **methodology and scientific principal towards** hazards for human adjustments and perception by sharing technological knowledge from **other engineering branches.**	2
	PO 6	Understanding of the need for a **high level of professional and ethical conduct in engineering** for human adjustments, perception with effective **management strategies**for disaster mitigation.	4
CO 6	PO 1	Understand the **knowledge of scientific principal and methodology** in disaster phenomenon for minimizing impact by implementing the Disaster Risk Reduction Strategy.	2
	PO 6	**Appropriate management strategies** are to be applied to reduce the level of risk in disaster mitigation.	1
	PO 9	Apply disaster risk reduction strategy using vrious organizations and **work effetively as an individual** and **as a member** or **a leader** are to be applied to reduce the level of risk in disaster mitigation.	3

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	Program Outcomes/ No. of Key Competencies Matched												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	1	2	3
CO 1	2	-	-	-	-	-	2	-	-	-	-		-	-	-
CO 2	1	-	-	-	-	4	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	4	2	-	-	-	-		-	-	-
CO 4	-	-	-	-	-	4	2	-	-	-	-	-	-		-
CO 5	2	-	-	-	-	4	-	-	-	-	-	-	-	-	-
CO 6	2	-	-	-	-	1	-	-	3	-	-	-	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	1	2	3
CO 1	66.6	-	-	-	-	-	66.6	-	-	-	-	-	-	-	-
CO 2	33.3	-	-	-	-	80	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	80	66.6	-	-	-	-	-	-		-
CO 4	-	-	-	-	-	80	66.6	-	-	-	-	-	-	-	-
CO 5	66.6	-	-	-	-	80	-	-	-	-	-	-	-	-	-
CO 6	66.6	-	-	-	-	20	-	-	25	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - $0 \leq C \leq 5\%$ – No correlation
1 - $5 \leq C \leq 40\%$ – Low/ Slight
2 - $40\% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	1	2	3
CO 1	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 2	1	-	-	-	-	3	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	3	3	-	-	-	-	-	-	-	-
CO 4	-	-	-	-	-	3	3	-	-	-	-	-	-		-
CO 5	3	-	-	-	-	3	-	-	-	-	-	-	-	-	-
CO 6	3	-	-	-	-	1	-	-	1	-	-	-	-	-	-
TOTAL	10	-	-	-	-	13	9	-	1	-	-	-	-	-	-
AVERAGE	3	-	-	-	-	3	3	-	1	-	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Term Paper	-	Concept Video	✓	Open Ended Experiments	-
Assignments	-	Mini project	-	Tech Talk	✓

XVII ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of mini projects by Experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**ENVIRONMENTAL HAZARDS AND DISASTERS**
	Environmental hazards and disasters: meaning of environmental hazards, environmental disasters and environmental stress; concept of environmental hazards, environmental stress and environmental disasters, different approaches and relation with human ecology, landscape approach, ecosystem approach, perception approach, human ecology and its application in geographical researches.
MODULE II	**TYPES OF ENVIRONMENTAL HAZARDS AND DISASTERS**
	Types of environmental hazards and disasters: Natural hazards and disasters, man induced hazards and disasters, natural hazards, planetary hazards/ disasters, extra planetary hazards/ disasters, planetary hazards, endogenous hazards, exogenous hazards.

MODULE III	**ENDOGENOUS HAZARDS**
	Endogenous hazards, volcanic eruption, earthquakes, landslides, volcanic hazards/ disasters, causes and distribution of volcanoes, hazardous effects of volcanic eruptions, environmental impacts of volcanic eruptions. Earthquake hazards/ disasters, causes of earthquakes, distribution of earthquakes, hazardous effects of, earthquakes, earthquake hazards in India,human adjustment, perception and mitigation of earthquake.
MODULE IV	**EXOGENOUS HAZARDS**
	Exogenous hazards/disasters, infrequent events, cumulative atmospheric hazards/disasters; Infrequent events: Cyclones , lightning , hailstorms; Cyclones: Tropical cyclones and local storms, destruction by tropical cyclones and local storms (causes, distribution human adjustment, perception and mitigation); Cumulative atmospheric hazards/ disasters: Floods, droughts, cold waves, heat waves floods; Causes of floods, flood hazards India, flood control measures (human adjustment, perception and mitigation); Droughts:Impacts of droughts, drought hazards in India, drought control measures,extra planetary hazards/ disasters, man induced hazards /disasters, physical hazards/ disasters, soil erosion, Soil erosion: Mechanics and forms of soil erosion, factors and causes of soil erosion, conservation measures of soil erosion; Chemical hazards/ disasters: Release of toxic chemicals, nuclear explosion, sedimentation processes; Sedimentation processes: Global sedimentation problems regional sedimentation problems, sedimentation and environmental problems, corrective measures of erosion and sedimentation,biological hazards/ disasters, population explosion.
MODULE V	**EMERGING APPROACHES IN DISASTER MANAGEMENT**
	Emerging approaches in Disaster Management, Three Stages 1. Pre, disaster stage(preparedness) 2. Emergency Stage 3. Post Disaster stage, Rehabilitation.

TEXTBOOKS

1. PardeepSahni, "Disaster Mitigation: Experiences and Reflections", PHI Learning Pvt. Ltd., 1 st Edition, 2001.
2. J.Glynn, GaryW.HeinKe, "Environmental Science and Engineering",Prentice Hall Publishers, 2 nd Edition, 1996.

REFERENCE BOOKS:

1. R.B.Singh (Ed), "Environmental Geography", 2nd Edition, 1990.
2. R.B. Singh (Ed), "Disaster Management", 2nd Edition, 2006.
3. Donald Hyndman "Natural Hazards and Disasters" - 5th edition, 2017.

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be a changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Course Objectives, Course Outcomes, Program Outcomes, CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
2	Classify Environmental Hazards & Disasters	CO 1	T2:26.3, R2: 3.1
3	Understand the Meaning of Environmental Hazards	CO 1	T2:2.2.2
4	Understand Environmental Stress	CO 1	T2:2.2.2, R3:3.7
5	Understand Environmental stress.	CO 2	T2:2.2.2
6	Obtain knowledge on Concept of Environmental Hazards	CO 2	T1:8.1
7	Capacity to analyze Environmental stress & Environmental Disasters	CO 2	T1:7.1, R2: 1.2
8	Capacity to analyze Ecology concept	CO 2	T2:3.2.3, R2: 1.3
9	Understand Different Approaches	CO 3	T2:4.2.3
10	Understand Landscape Approach -.	CO 3	T2:4.5.2
11	Explain Ecosystem approach -Perception approach.	CO 3	T2:4.7.9
12	Understand Human ecology & its application in geographical researches	CO 4	T2:5.2.1, R2: 6.4
13	Understand Human ecology & its application in geographical researches	CO 4	T2:5.2.1, R2: 6.4
14	Understand Types of Environmental hazards & Disasters	CO 4	T2:5.4
15	Capacity to analyze and evaluate Natural hazards and Disasters	CO 3	T2:5.5.3
16	Capacity to analyze and evaluate Natural hazards and Disasters	CO 3	T2:5.5.3
17	Understand Man induced hazards & Disasters	CO 3	T2:6.2.2
18	Understand Man induced hazards & Disasters	CO 3	T2:6.2.2
19	Obtain knowledge on Natural Hazards- Planetary Hazards/ Disasters	CO 4	R1:2.5, R2: 8.2
20	Obtain knowledge on Natural Hazards- Planetary Hazards/ Disasters	CO 4	R1:2.5, R2: 8.2
21	Analyze the Planetary Hazards-Endogenous Hazards - Exogenous Hazards	CO 4	R2:2.2.5, R2: 9.2
22	Analyze the Planetary Hazards-Endogenous Hazards - Exogenous Hazards	CO 4	R2:2.2.5, R2: 9.2

23	Understand Volcanic Eruption – Earthquakes – Landslides	CO 4	R3:5.4.8, R2: 9.6
24	Understand Volcanic Eruption – Earthquakes – Landslides	CO 4	R3:5.4.8, R2: 9.6
25	Volcanic Hazards/Disasters- Causes and distribution of Volcanoes	CO 4	T2:8.1.2
26	Volcanic Hazards/Disasters- Causes and distribution of Volcanoes	CO 4	T2:8.1.2
27	Explain the Hazardous effects of volcanic eruptions	CO 4	T2:8.3.5, R2: 5.3
28	Explain the Hazardous effects of volcanic eruptions	CO 4	T2:8.3.5, R2: 5.3
29	Understand Environmental impacts of volcanic eruptions - Earthquake Hazards/ disasters - Causes of Earthquakes	CO 4	T2:8.5
30	Understand Environmental impacts of volcanic eruptions - Earthquake Hazards/ disasters - Causes of Earthquakes	CO 4	T2:8.5
31	Distribution of earthquakes - Hazardous effects of - earthquakes - Earthquake Hazards in India	CO 4	T2:8.9.2
32	Explain the Droughts: Impacts of droughts, Drought hazards in India	CO 5	T2:9.2, R3: 4.6
33	Explain the Droughts: Impacts of droughts, Drought hazards in India	CO 5	T2:9.2, R3: 4.6
34	Understand Extra Planetary Hazards/ Disasters- Man induced Hazards /Disasters	CO 5	T2:9.2, R3: 4.7
35	Understand Extra Planetary Hazards/ Disasters- Man induced Hazards /Disasters	CO 5	T2:9.2, R3: 4.7
36	Understand the Infrequent events: Cyclones, Lightning, Hailstorms, Cyclones: Earthquake Hazards in India	CO 5	T2:9.5.3
37	Understand the Infrequent events: Cyclones, Lightning, Hailstorms, Cyclones: Earthquake Hazards in India	CO 5	T2:9.5.3
38	Analyze the Tropical cyclones and Local storms	CO 5	T2:9.6.2, R3: 8.5
39	Understand the Destruction by tropical cyclones and local storms (causes, distribution human adjustment, perception and mitigation)	CO 5	T2:9.7.5, R3: 8.12
40	Understand the Destruction by tropical cyclones and local storms (causes, distribution human adjustment, perception and mitigation)	CO 5	T2:9.7.5, R3: 8.12
41	Analyze the Cumulative atmospheric hazards/ disasters : Floods, Droughts, Cold waves, Heat waves Floods	CO 5	T2:9.5.4
42	Analyze the Cumulative atmospheric hazards/ disasters : Floods, Droughts, Cold waves, Heat waves Floods	CO 5	T2:9.5.4
43	Identification of Flood control measures (Human adjustment, perception and mitigation),	CO 6	T2:9.5.4

44	Identification of Flood control measures (Human adjustment, perception and mitigation),	CO 6	T2:9.5.4
45	Analyze the Exogenous hazards/ disasters - Infrequent events- Cumulative atmospheric hazards/ disasters	CO 6	T2:9.5.6
PROBLEM SOLVING/ CASE STUDIES			
1	Case study on modern disaster management system	CO 1	T2:2.2.2
2	Case study on natural disaster	CO 2	T2:2.2.2
3	Case study on manmade disaster	CO 3	T2:2.2.2
2	Case study on Latur earthquake	CO 4	T2:2.2.2
4	Case study on Fukushima Nuclear disaster	CO 4	T2:2.2.2, R3:3.7
5	Case study on tsunami occurred in Japan	CO 5	T2:2.2.2
6	Case study on Hiroshima and Nagasaki	CO 4	T1:8.1
7	Case study on Russian Siberia oil spill	CO 4	T1:7.1, R2: 1.2
8	Case study on Hudhud Cyclone 2014	CO 5	T2:3.2.3, R2: 1.3
9	Case study on South India Floods 2015	CO 5	T2:4.2.3
10	Case study on Bihar Heat Wave 2019	CO 5	T2:4.5.2
11	Case study on Bihar Floods 2019	CO 5	T2:4.7.9
12	Case study on Oil Spillage in Russia 2020	CO 4	T2:5.4
13	Case study on Yellow River Flood in china	CO 4	T2:5.5.3
14	Case study on Bhola Cyclone Bangladesh	CO 5	T2:6.2.2
15	Causes of wildfires and effects	CO 4	T2:9.5.4
16	pre-disaster activities to reduce the impact of cyclones	CO 5	T2:9.5.4
17	Tectonic plate theory	CO 4	T2:9.5.6
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Different approaches and relation with human ecology, landscape approach, ecosystem approach, perception approach	CO 1	T2:2.2.2
2	Natural hazards, planetary hazards/ disasters, extra planetary hazards/ disasters, planetary hazards, endogenous hazards, exogenous hazards	CO 2	T2:2.2.2, R3:3.7
3	Effects of volcanic eruptions, environmental impacts of volcanic eruptions	CO 3, CO 4	T2:2.2.2
4	Lightning , hailstorms; Cyclones: Tropical cyclones and local storms, destruction by tropical cyclones and local storms (causes, distribution human adjustment, perception and mitigation); Cumulative atmospheric hazards/ disasters:	CO 5	T1:8.1
5	Emerging approaches in Disaster Management, Three Stages 1. Pre, disaster stage(preparedness), 2. Emergency Stage ,3. Post Disaster stage, Rehabilitation.	CO 6	T1:7.1, R2: 1.2

DISCUSSION OF QUESTION BANK			
1	Environmental hazards and disasters	CO 1	R1:2.1
2	Types of environmental hazards and disasters	CO 2	T4:7.3
3	Endogenous hazards, volcanic eruption, earthquakes, landslides, volcanic hazards/ disasters, causes and distribution of volcanoes, hazardous effects of volcanic eruptions, and their environmental impacts.	CO 3, CO 4	R2:5.1
4	Global sedimentation problems regional sedimentation problems, sedimentation and environmental problems, corrective measures of erosion and sedimentation,biological hazards/ disasters, population explosion.	CO 5	T1:7.5
5	Emerging approaches in disaster management	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,CE**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING
COURSE DESCRIPTION

<table>
<tr><td>Course Title</td><td colspan="5">Thermo-Fluid Modelling and Simulation Laboratory</td></tr>
<tr><td>Course Code</td><td colspan="5">AMEC37</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td>VI</td><td colspan="4">ME</td></tr>
<tr><td>Course Type</td><td>Core</td><td colspan="4"></td></tr>
<tr><td>Regulation</td><td>IARE - UG 20</td><td colspan="4"></td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>3</td><td>1.5</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Mr. P. Venkata Mahesh, Assistant Professor</td></tr>
</table>

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC09	III	Materials and Mechanics of Solids Laboratory Laboratory
B.Tech	AMEC16	IV	Fluid Mechanics and Hydraulic Machines Laboratory

II COURSE OVERVIEW:

The Thermo-Fluid modeling and simulation laboratory sessions are focusing on creation of geometry, meshing (Discretization) and the physics applied to fluid thermal systems in order to visualize fluid flow and temperature distribution, solving, and reviewing results. The ANSYS software has different modulus (Ansys, CFX, Fluent etc...). The Workbench environment is an intuitive up-front finite element analysis tool that is used in conjunction with CAD systems and/or Design Modeler. ANSYS Workbench is a software environment for performing structural, thermal, and fluid flow analyses. TFMS laboratory also covers the usage of finite element methods and necessary coding techniques in the interpretation of results.These simulations are used in performing structural, thermal, and electromagnetic systems in the emerging technologies of interdisciplinary applications such as mechanical, aerospace, refrigeration systems.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Programming in Logic Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

X	Demo Video	X	Lab Worksheets	X	Viva Questions	X	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
-	-	-	-	-	-

VI COURSE OBJECTIVES:

The students will try to learn:

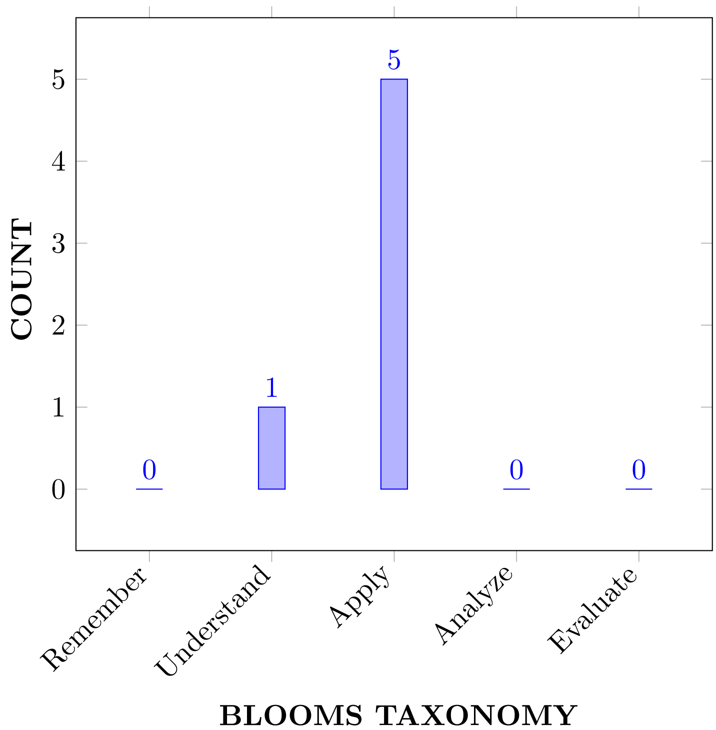
I	The formulation of the problem, discretization and suitable boundary conditions by using commercial packages.
II	The basic comertial packages that provide the data and contours in the prediction the performance of thermo fluid systems..
III	The environment and usage of commercial Computational Fluid Dynamics packages to carry out research in interdisciplinary applications.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Demonstrate** the application of finite element method for analyzing 2D fluid flow problems. .	Understand
CO 2	**Make use of** AnsysCFX or Solid Works Flow Simulation for analyzing simple fluid flow problems.	Apply
CO 3	**Develop** the Matlab code for analyzing 2D fluid flow problems.	Apply
CO 4	**Make use of** Ansys or Solid Works Flow Simulation for analyzing simple heat transfer problems.	Apply
CO 5	**Make use of** AnsysFluent for analyzing conjugate heat transfer.	Apply
CO 6	**Make use of** Ansys for analyzing stress in Beam.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises/ CIE/ SEE

PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	Lab Exercises/ CIE/ SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	Lab Exercises/ CIE/ SEE
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Lab Exercises/ CIE/ SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	Lab Exercises/ CIE/ SEE
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	Lab Exercises/ CIE/ SEE
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	3	Lab Exercises/Projects
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Lab Exercises/ CIE/ SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Lab Exercises/ CIE/ SEE
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2	Lab Exercises/Projects
PO 12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	Lab Exercises/Projects

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	3	Lab Exercises/ CIE/ SEE
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	2	Lab Exercises/ CIE/ SEE

3 = High; 2 = Medium; 1 = Low

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COs	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	2	2	3	2	-	3	2	2	2	2	-	3	-
CO2	3	3	2	2	3	2	-	3	2	2	2	2	-	3	2
CO3	3	3	2	2	3	2	-	3	2	2	2	2	-	3	2
CO4	3	3	2	2	3	2	-	3	2	2	2	2	-	3	2
CO5	3	3	2	2	3	2	-	3	2	2	2	2	-	3	2
CO6	3	3	2	2	3	2	-	3	2	2	2	2	-	3	2

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**INTERNAL PIPE FLUID FLOW – FEM**
	Internal Pipe flow problem Using theoretical FEM.
WEEK II	**INTERNAL PIPE FLUID FLOW - ANSYS**
	Analyzing Flow in a System of Pipes using ANSYS.
WEEK III	**INTERNAL PIPE FLUID FLOW – MATLAB**
	Internal Pipe flow problem using MAT LAB.

WEEK IV	**EXTERNAL FLUID FLOW**
	to analyze fluid flowing over the surface of the plate using ANSYS CFX Simulation.
WEEK V	**FLOW THROUGH BALL VALVE**
	Flow of water through a ball valve assembly using ANSYS/ Solid Works Flow Simulation.
WEEK VI	**HEAT CONDUCTION**
	Heat Conduction within a Solid using ANSYS.
WEEK VII	**TEMPERATURE DISTRIBUTION**
	Temperature distribution in a fin cooled electronic component using ANSYS.
WEEK VIII	**3D HEAT CONDUCTION**
	3D Heat Conduction within a Solid-Cell Phone using ANSYS.
WEEK IX	**COUNTER FLOW HEAT EXCHANGER**
	Calculation of the efficiency of the counter flow heat exchanger using ANSYS/SolidWorks Flow Simulation. .
WEEK X	**CONJUGATE HEAT TRANSFER**
	Conjugate heat transfer problem using ANSYS/ Solid Works Flow Simulation.
WEEK XI	**3D THERMAL ANALYSIS**
	3D Thermal Analysis, Finned Pipe using ANSYS.
WEEK XII	**THERMAL STRESS ANALYSIS**
	Thermal stress analysis in a beam.

TEXTBOOKS

1. J. D. Anderson, (Jr), "Computational Fluid Dynamics", McGraw-Hill Book Company, 1st Edition, 1995.
2. K.A.Hoffman, and S. T. Chiang, "Computational Fluid Dynamics", Vol. I, II and III, Engineering Education System, Kansas, USA, 2000.
3. D. A. Anderson, J. C. Tannehill, and R. H. Pletcher, "Computational Fluid Mechanics and Heat Transfer", McGraw Hill Book Company, 2002.

REFERENCE BOOKS:

1. J Chung, T.J., "Computational Fluid Dynamics", Cambridge University Press, 2003
2. Muralidhar K and Sundararajan. Computational Fluid Flow and Heat Transfer", 2009.

1. https://courses.ansys.com/
2. https://www.udemy.com/course/ansys-tutorial/

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	Internal Pipe flow problem Using theoretical FEM.	CO 1	T1: 1.4
2	Analyzing Flow in a System of Pipes using ANSYS .	CO 2	T2: 1.5
3	Internal Pipe flow problem using MAT LAB.	CO 3	T1: 2.5
4	External flow over Plate analysis using ANSYS.	CO 2	R1: 2.6
5	Flow of water through a ball valve assembly using ANSYS/ Solid-Works Flow Simulation.	CO 2	T2: 2.7
6	Heat Conduction within a Solid using ANSYS.	CO 4	R1: 5.3
7	Temperature distribution in a fin cooled electronic Component using ANSYS.	CO 4	T1: 7.5
8	3D Heat Conduction within a Solid-Cell Phone using ANSYS.	CO 4	R1: 6.8
9	Calculation of the efficiency of the counter flow heat exchanger using ANSYS/Solid-Works Flow Simulation.	CO 5	T1: 12.2
10	Conjugate heat transfer problem using ANSYS/Solid Works Flow Simulation .	CO 5	R1:13.2
11	3d thermal analysis.	CO 5	R2:13.7
12	Thermal stress analysis.	CO 6	R3:10.2

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design and analyse a heat exchanger for the given cold and hot fluid conditions.
2	Design and analyse the centrifugal pump for the given head and discharge.
3	Analyse different shapes of fins for finding the optimum fin shape for maximum heat transfer.
4	Analyse different aerofoil shapes to find the optimum shape for the desired lift and drag.
5	Analyse the heat transfer through the different materials to find the best for the given conditions.

Signature of Course Coordinator **(HOD.ME)**
Dr. P.Venkata Mahesh, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**HEAT TRANSFER LABORATORY**				
Course Code	AMEC36				
Program	B. Tech				
Semester	VI				
Course Type	Laboratory				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Dr.K.China Apparao, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AMEB13	IV	Fluid Machinery and IC Engines lab	2

II COURSE OVERVIEW:

Heat transfer laboratory is intended to enhance the learning experience of the student about the flow of thermal energy due to temperature difference and the subsequent temperature distribution changes. This laboratory focuses on heat transfer modes, boundary conditions, one dimensional steady and unsteady state condition and heat exchangers applied to modern electric and electronic plants require efficient dissipation of thermal losses. Students are expected to gain experience in hands on training as well as knowledge to model heat exchangers, heat treatment of fins and complex mechanical systems.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Heat Transfer Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing Further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day-to-day performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the principal from the panel of experts recommended by Chairman, BOS.

The emphasis on the experiments is broadly based on the following criteria 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.

A. Experiment Based

Objective	**Analysis**	**Design**	**Conclusion**	**Viva**	**Total**
2	2	2	2	2	10

B. Programming Based

Purpose	**Algorithm**	**Program**	**Conclusion**	**Viva**	**Total**
-	-	-	-	-	-

VI PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
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PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

VII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Experiments/CIE/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Lab Experiments/CIE/SEE
PO 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	2	Lab Experiments/CIE/SEE
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Lab Experiments/CIE/SEE

3 = High; 2 = Medium; 1 = Low

VIII HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

IX COURSE OBJECTIVES:

The students will try to learn:

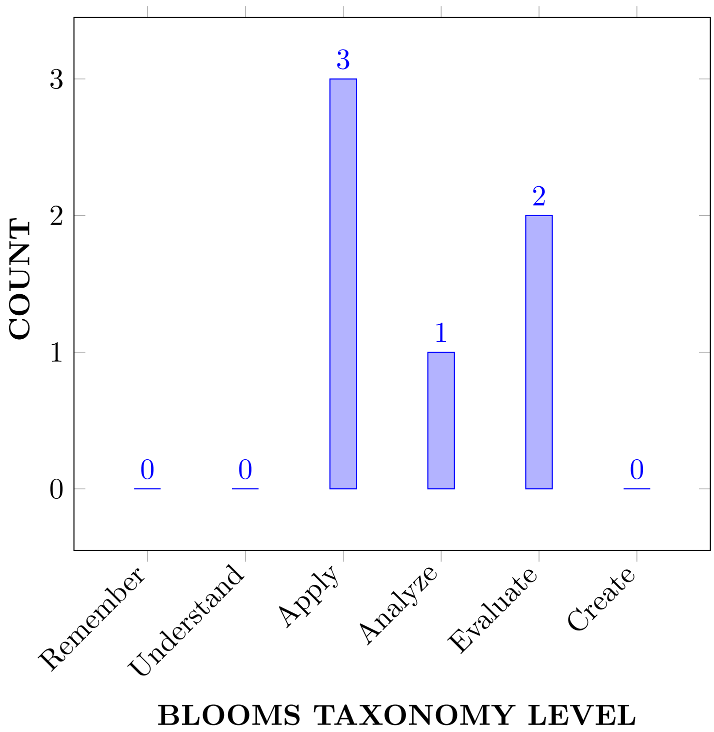
I	The information for validating heat transfer parameters during internal and external flows based on non-dimensional numbers and convective mode heat transfer.
II	Enhance the performance and analysis of heat exchangers for real-time applications using logarithmic mean temperature difference and number of transfer unit methods.
III	Compare experimental results with theoretical to improve the design for improving the efficiency of heat transfer rate.

X COURSE OUTCOMES:

After successful completion of the course, students should be able to:

Course Outcomes		Knowledge Level (Bloom's Taxonomy)
CO 1	**Identify** the steps involved with different surfaces and geometries for which the temperature distribution and heat flow rates are calculated for automotive industry components like radiators, engine blocks.	Apply
CO 2	**Examine** the principles associated with convective heat transfer to formulate and calculate the dynamics of temperature field in fluid flow for real time applications.	Analyze
CO 3	**Select** the appropriate convection equations for solving heat transfer rate in cylinders and spheres.	Apply
CO 4	**Build** the phenomena of boiling and condensation to give various correlations applied to heat exchangers, boilers, heat engines, etc.	Evaluate
CO 5	**Select** the appropriate expression for overall heat transfer coefficient for modelling heat exchanger to achieve defect/error free components.	Evaluate
CO 6	**Identify** the appropriate parameters for enhancing heat transfer rates in heat exchangers.	Apply

COURSE COURSE KNOWLEDGE COMPETENCY LEVEL:



XI PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
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PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
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PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing of a product and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and engineering fundamentals.	2
	PO 2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to pin fin for heat transfer enhancement.	2
CO 2	PO 1	Identify (knowledge) in suitable methods involved during heat exchangers using in solving (complex) engineering problems by applying the principles of mathematics and engineering fundamentals	2
	PO 2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to convection in identification of process adoption to special develop of a component.	2
CO 3	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing of a product and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and engineering fundamentals.	2
	PO 5	Create, select, and apply convection, radiation resources, and modern engineering tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	2
CO 4	PO 1	Recall (knowledge) the basic mechanisms and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and engineering fundamentals.	2
	PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	2
CO 5	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing of a product and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and engineering fundamentals.	2
	PO 5	Create, select, and apply convection, radiation resources, and modern engineering tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	2

	PO 9	Design and develop the heat exchangers effectively as an individual, and as a member in diverse teams, and in multidisciplinary settings for designing of modern heat exchagers.	2
CO 6	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing of a product and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and engineering fundamentals.	2
	PO 5	Create, select, and apply convection, radiation resources, and modern engineering tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	2
	PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	2

3 = High; 2 = Medium; 1 = Low

XIII MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES				Program Specific Outcomes
	PO 1	PO 2	PO 5	PO 9	PSO 2
CO 1	2	2			
CO 2	2	2			
CO 3	2		2		
CO 4	2				2
CO 5	2		2	2	
CO 6	2		2		2

3 = High; 2 = Medium; 1 = Low

XIV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	✓	Mini projects	-		

XV ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVI SYLLABUS:

WEEK 1	**Composite slab apparatus-Overall heat transfer coefficient**
	Objective: Calculating the overall heat transfer coefficient for a composite slab. **Solutions Expected:** 1. Start the main switch. By adjusting the dimmer knob give heat input to heater. (Say 60V). and wait for about 20 -30 min. approximately to reach steady state. 2. Measure the temperatures of composite carefully and calculate individual and overall thermal conductivity of the composite slab
WEEK 2	**Heat transfer through lagged pipe**
	Objective: Determine the thermal conductivity of coaxial cylindrical surface . **Solutions Expected:** 1. Start the main switch. By adjusting the dimmer knob give heat input to heater. (Say 60V). and wait for about 20 -30 min. approximately to reach steady state. 2. Measure the temperatures of cylindrical surfaces carefully and calculate overall heat transfer coefficient and overall thermal conductivity of the coaxial cylindrical surface
WEEK 3	**Heat transfer through concentric sphere**
	Objective: Determination of thermal conductivity 0f insulating powder. **Solutions Expected:** 1. Operate the dimmer stat slowly to increase the heat input to the heater and adjust the voltage to any desired voltage (do not exceed 150V) and Maintain the same heat input throughout the experiment until the temperature reaches a steady state 2. Determine the thermal conductivity of insulating powder at various heat inputs
WEEK 4	**Thermal conductivity of given metal rod**
	Objective: Determine the thermal conductivity of the metal rod. **Solutions Expected:** 1. Give heat input to the heater by slowly rotating the dimmer and adjust the voltage to say 60 V, 80 V, etc. and allow sufficient time for the apparatus to reach steady state. Take readings of voltmeter and ammeter. 2. Determine the thermal conductivity of metal rod at various heat inputs

<table>
<tr><td>WEEK 5</td><td>Heat transfer in Pin fin apparatus</td></tr>
<tr><td></td><td>Objective: Calculate the effectiveness and efficiency of pin fin.
Solutions Expected:
1. Adjust the power input to the heater to desired value and switch on the blower then set the air–flow rate to any desired value by adjusting the difference in water levels in the manometer and allow the unit to stabilize.
2. Determine the temperature of a pin-fin for forced convection and calculate fin efficiency and effectiveness</td></tr>
<tr><td>WEEK 6</td><td>Experiment on transient heat conduction</td></tr>
<tr><td></td><td>Objective: Determine the thermal conductivity specimen in transient mode.
Solutions Expected:
1. Measure the specimen temperature at any interval of time by practical and by theoretical methods and observe the heating and cooling curves of unsteady state.
2. Determine the thermal conductivity specimen in unsteady state condition.</td></tr>
<tr><td>WEEK 7</td><td>Heat transfer in forced convection apparatus</td></tr>
<tr><td></td><td>Objective: Calculate convective heat transfer coefficient in forced convection.
Solutions Expected:
1. Measure the surface temperature of the tube wall is measured at different sections using thermo couples embedded in the walls
2. Determine the convective heat transfer coefficient and the rate of heat transfer by forced convection for flow of air inside a horizontal pipe</td></tr>
<tr><td>WEEK 8</td><td>Heat transfer in natural convection apparatus</td></tr>
<tr><td></td><td>Objective: Calculating convective heat transfer coefficient.
Solutions Expected:
1. Measure the surface temperature of the tube wall is measured at different sections using thermo couples embedded in the walls
2. Determine the convective heat transfer coefficient and the rate of heat transfer under natural convection for flow of air inside a horizontal pipe</td></tr>
</table>

WEEK 9	**Parallel and counter flow heat exchangers**
	Objective: Calculate the effectiveness of heat exchangers both experimental and theoretical method. **Solutions Expected:** 1. Adjust the flow rate of hot water and cold water by using rotameters and valves and Keep the flow rate same till steady state conditions are reached then measure the temperature of fluids 2. Determine the overall heat transfer coefficient of parallel flow and counter flow heat exchangers, also calculate effectiveness and efficiency of Heat exchangers
WEEK 10	**Emissivity apparatus**
	Objective: Determination of emissivity of grey and black body. **Solutions Expected:** 1. Give same power input to both the heater by adjusting dimmer. When steady state is reached measure the temperatures by rotating the temperature selection switch gently 2. Determine the emissivity of grey body and rate of heat transfer from black body to grey body by radiation
WEEK 11	**Stefan Botlzman apparatus**
	textbf Objective: Determination of Stefan Botlzman constant and compare its value. **Solutions Expected:** 1. Give same power input to both the heater by adjusting dimmer. When steady state is reached measure the temperatures by rotating the temperature selection switch gently 2. Determine the Stefan Boltzmann constant y and rate of heat transfer
WEEK 12	**Critical heat flux apparatus**
	textbf Objective: Evaluate the critical heat flux value by studying different zones of boiling. **Solutions Expected:** 1. The bulk water is switched on and kept on, until the required bulk temperature of water is obtained The voltage is increased further and a point is reached when wire breaks (melts) and at this point voltage and current are noted 2. Evaluate the critical heat flux value by studying different zones of boiling.

TEXTBOOKS

1. Yunus A. Cengel,Heat Transfer a Practical Approach, Tata McGraw hill education (P) Ltd, New Delhi, 4th Edition, 2012.

2. R. C. Sachdeva, Fundamentals of Engineering, Heat and Mass Transfer, New Age, New Delhi, India, 3rd Edition, 2012.

REFERENCE BOOKS:

1. Holman, Heat Transfer, Tata McGraw-Hill Education, 10th Edition, 2011.
2. P. S. Ghoshdastidar, Heat Transfer, Oxford University Press, 2nd Edition, 2012.
3. D. S. Kumar, Heat and Mass Transfer, S.K. Kataria & sons, 9th Edition 2015.

XVII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Composite slab apparatus-Overall heat transfer coefficient	CO1, CO 2	T2:2.3
2	Heat transfer through lagged pipe	CO1, CO 2	R1:2.6
3	Heat transfer through concentric sphere	CO 1, CO 2, CO 3, CO 4	T1:2.6
4	Thermal conductivity of given metal rod	CO 2, CO 3, CO 4	T2:2.7 R1:2.18
5	Heat transfer in Pin fin apparatus	CO 3, CO 4	T2:2.22
6	Experiment on transient heat conduction	CO 3, CO 5	T2:2.25
7	Heat transfer in forced convection apparatus	CO 4, CO 3	T2:2.26 R1:2.55
8	Heat transfer in natural convection apparatus	CO 3, CO 4	T2:2.3
9	Parallel and counter flow heat exchangers	CO 4	R1:2.6
10	Emissivity apparatus	CO 5	T1:2.6
11	Stefan Botlzman apparatus	CO 5	T2:2.7 R1:2.18
12	Critical heat flux apparatus	CO 5, CO 6	T2:2.22

XVIII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design and development of Heat Exchangers for effective dissipation of heat from radiators.
2	Design of fin for constant base temperature under natural and force flow conditions
3	Design and development of emissivity measurement apparatus for the non – black surface and compare with the black body.
4	Design the convective and radiation heat transfer coefficient at each zone and compare them to decide the critical thickness of insulation
5	Design and development of forced convection apparatus for effective heat transfer through extended surfaces.

Prepared by: **HOD, ME**

Dr.K.China Apparao, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
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Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**DESIGN FOR MANUFACTURING**				
Course Code	AMEC42				
Program	B.Tech				
Semester	VII				
Course Type	Professional Elective				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	0	0
Course Coordinator	Mr.B.VijayaKrishna, Assistant Professor.				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC11	IV	Manufacturing Processes
B.Tech	AMEC19	V	Machine Tools and Metrology

II COURSE OVERVIEW:

Design for manufacturing is an engineering methodology that focuses on reducing time-to-market and total production costs by prioritizing both the ease of manufacture for the products parts and the simplified assembly of those parts into the final product.The main objective of this course is to design a product for part minimization, quantitative analysis of a design's efficiency, critique product designs for ease of assembly and the importance of involving production engineers in DFMA analysis.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total
Design for Manufacturing	70 Marks	30 Marks	100 Marks

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), and 10 marks for Alternative Assessment Tool (AAT).

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
16%	Remember
50%	Understand
33%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
	Continuous Internal Examination – 2 (Mid-term)	10	
	AAT-1	5	
	AAT-2	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			100

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

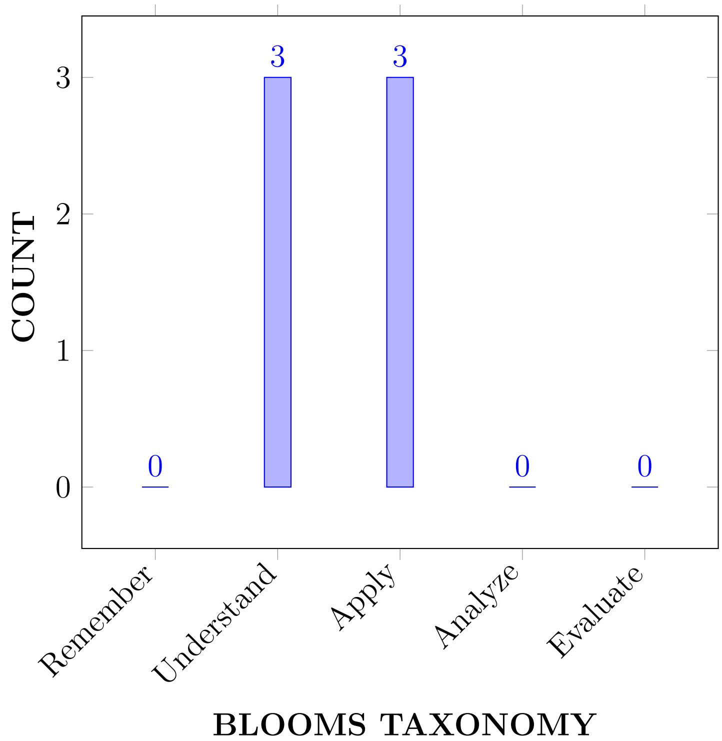
I	To apply the techniques of design for manufacturing and assembly applied for minimizing product cost through design and process improvements.
II	To understnad selection of material and process used in the prototype design in the early stages of product development for cost effectiveness.
III	To identify the manufacturing constraints that influence the design of parts and part systems
IV	To minimize pattern movement in assembly process and assembly errors by considering logical sub-assemblies and re-orientation of parts during machining.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Identify** the concepts of design for manufacturing for product development which minimizes part count in manufacturing process.	Understand
CO 2	**Make use** of the suitable materials for product manufacturing in engineering applications to eliminate expensive and complex features.	Understand
CO 3	**Select** the proper gating and riser system needed for casting requirements to achieve defect/error free components.	Apply
CO 4	**Categorize** various defects and shortcomings during gas welding operation such as TIG, MIG and Spot welding for real time applications.	Understand
CO 5	**Apply** principles of design for manufacturing processes manual and automated assembly, economical production and material selection.	Apply
CO 6	**Outline** impact of various stresses acting on screw threads to minimise failure rate for enhancing power transmission systems.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Program Outcomes	
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/AAT
PO 4	**Conduct Investigations of Complex Problems** : Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	CIE/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	3	AAT

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	✓	-		-	-	-	-	-	-	-	-	-	-
CO 5	-	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 6	✓	✓	-	-		-	-	-	-	-	-	-	✓	-	

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall (knowledge) the basic steps involved in robotics and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and physics and engineering fundamentals.	3
CO 2	PO 1	Recall (knowledge) the basic steps involved in robotics and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and physics and engineering fundamentals.	3
	PO2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design.	2
CO3	PO4	Investigate prototype models based on constraint including Environmental sustainability, Health and safety risks assessment issues and define specific problem.	3
CO4	PO3	Design the solution for problems of voltage doublers and multiplier circuits.	2
CO5	PO2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design.	2
	PSO1	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.	2
CO6	PO 1	Recall (knowledge) the basic steps involved in robotics and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and physics and engineering fundamentals.	3
	PO2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design.	2
	PSO1	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-		2	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	100	-	-	-	-	-	-	-		-	-	-
CO 4	-	-	50	-		-	-	-	-	-	-	-	-	-	-
CO 5	-	50	-	-	-	-	-	-	-	-	-	-	50	-	-
CO 6	100	50	-	-		-	-	-	-	-	-	-	50	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
TOTAL	9	6	2	3	-	-	-	-	-	-	-	-	6	-	-
AVERAGE	3	2	2	3	-	-	-	-	-	-	-	-	3	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments	✓	Tech Talk	✓		

XVII ASSESSMENT METHODOLOGY-INDIRECT:

X	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO DFM**
	Introduction: Design philosophy, steps in design process, general design rules for manufacture ability, basic principles of designing for economical production, creativity in design; materials: Selection of materials for design, developments in material technology, criteria for material selection, and material selection interrelationship with process selection, process selection charts.
MODULE II	**DESIGN FOR MACHINING AND MOULDING**
	Machining Process: Overview of various machining processes, general design rules for machining, dimensional tolerance and surface roughness, design for machining ease, redesigning of components for machining ease with suitable examples, general design recommendations for machined parts. Plastics: Viscoelastic and Creep behavior in plastics – Design guidelines for Plastic components – Design considerations for Injection Moulding
MODULE III	**DESIGN FOR METAL CASTING AND METAL JOINING**
	Metal Casting: Appraisal of various casting processes, selection of casting process, - general design considerations for casting - casting tolerances - use of solidification simulation in casting design - product design rules for sand casting, Metal Joining: Appraisal of various welding processes, Factors in design of weldments - general design guidelines - pre and post treatment of welds - effects of thermal stresses in weld joints - design of brazed joints. Forging - Design factors for Forging - Closed dies forging design - parting lines of dies drop forging die design - general design recommendations. Extrusion and Sheet Metal Work: Design guidelines for extruded sections - design principles for Punching, Blanking, Bending, Deep Drawing - Keeler Goodman Forming Line Diagram - Component Design for Blanking
MODULE IV	**DEVELOPMENT OF THE ASSEMBLE PROCESS**
	Development of the assemble process, choice of assemble method assemble advantages social effects of automation. Automatic Assembly Transfer Systems: Continuous transfer, intermittent transfer, indexing mechanisms, and operator - paced free – transfer machine

MODULE V	**DESIGN OF MANUAL ASSEMBLY**
	Design for assembly fits in the design process, general design guidelines for manual assembly, development of the systematic DFA methodology, assembly efficiency, classification system for manual handling, classification system for manual insertion and fastening, effect of part symmetry on handling time, effect of part thickness and size on handling time, effect of weight on handling time, parts requiring two hands for manipulation, effects of combinations of factors, effect of symmetry effect of chamfer design on insertion operations, estimation of insertion time

TEXT BOOKS

1. Geoffrey Boothroyd, "Assembly Automation and Product Design", Marcel and Dekken, Inc., 2nd Edition, 2021.
2. George E. Deiter, "Engineering Design - Material Processing Approach", McGraw Hill Intl. 2nd Edition, 2021.
3. Geoffrey Boothroyd," Hand Book of Product Design", Marcel and Dekken,, N.Y. 2nd Edition, 2021.

REFERENCE BOOKS:

1. Geoffrey Boothroyd, "Hand Book of Product Design", Marcel and Dekken, 1st Edition, 2021
2. Geoffrey Boothroyd, Peter Dewhurst, Winston, "Product Design for Manufacturing and Assembly", CRC Press, 1st Edition, 2021.

WEB REFERENCES:

1. //nptel.ac.in/courses/107103012/
2. //nptel.ac.in/courses/112101005

COURSE WEB PAGE:www.iare.ac.in./lms/dfm/Amec42.

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Introduction to Outcome Based Education		
CONTENT DELIVERY (THEORY)			
2	Design philosophy, steps in design process, general design rules for manufacture ability.	CO1	T2: 1.1-1.5, T1: 4.1
3	Basic principles of designing for economical production, creativity in design.	CO1	T2: 1.1-1.5, T1: 4.1
4	Materials: Selection of materials for design, developments in material technology.	CO1	T2: 1.1-1.5, T1: 4.1

5	Criteria for material selection, and material selection interrelationship with process selection.	CO1	T2: 1.1-1.5, T1: 4.1
6	Process selection charts.	CO1	T2: 1.1-1.5, T1: 4.1
7	Machining Process: Overview of various machining processes, general design rules for machining.	CO1	T2: 1.1-1.5, T1: 4.1
8	Dimensional tolerance and surface roughness, design for machining ease	CO1	T2: 1.1-1.5, T1: 4.1
9	Redesigning of components for machining ease with suitable examples, general design recommendations for machined parts	CO1	T2: 1.1-1.5, T1: 4.1
10	Plastics: Viscoelastic and Creep behavior in plastics – Design guidelines for Plastic components.	CO1	T2: 1.1-1.5, T1: 4.1
11	Behavior in plastics, Design guidelines for Plastic components.	CO2	T2: 1.1-1.5, T1: 4.1
12	Metal Casting: Appraisal of various casting processes.	CO2	T2: 1.1-1.5, T1: 4.1
13	Selection of casting process, - general design considerations for casting.	CO2	T2: 1.1-1.5, T1: 4.1
14	Casting tolerances, use of solidification simulation in casting design.	CO2	T2: 1.1-1.5, T1: 4.1
15	Product design rules for sand casting.	CO2	T2: 1.1-1.5, T1: 4.1
16	Appraisal of various welding processes, Factors in design of weldments.	CO2	T2: 1.1-1.5, T1: 4.1
17	General design guidelines - pre and post treatment of welds - effects of thermal stresses in weld joints.	CO2	T2: 1.1-1.5, T1: 4.1
18	Design of brazed joints.	CO2	T2: 1.1-1.5, T1: 4.1
19	Forging, Design factors for Forging, Closed dies forging design.	CO2	T2: 1.1-1.5, T1: 4.1
20	Parting lines of dies drop forging die design, general design recommendations.	CO2	T2: 1.1-1.5, T1: 4.1

21	Design guidelines for extruded sections, design principles for Punching, Blanking, Bending.	CO2	T2: 1.1-1.5, T1: 4.1
22	Deep Drawing, Keeler Goodman Forming Line Diagram, Component Design for Blanking.	CO2	T2: 1.1-1.5, T1: 4.1
23	Development of the assemble process.	CO2	T2: 1.1-1.5, T1: 4.1
24	Choice of assemble method assemble advantages.	CO2	T2: 1.1-1.5, T1: 4.1
25	Social effects of automation.	CO3	T2: 1.1-1.5, T1: 4.1
26	Continuous transfer, intermittent transfer, indexing mechanisms, and operator.	CO3	T2: 1.1-1.5, T1: 4.1
27	Paced free, transfer machine	CO3	T2: 1.1-1.5, T1: 4.1
28	Design for assembly fits in the design process.	CO3	T2: 1.1-1.5, T1: 4.1
29	General design guidelines for manual assembly.	CO3	T2: 1.1-1.5, T1: 4.1
30	Development of the systematic DFA methodology, assembly efficiency.	CO3	T2: 1.1-1.5, T1: 4.1
31	Classification system for manual handling.	CO4	T2: 1.1-1.5, T1: 4.1
32	Classification system for manual insertion and fastening.	CO4	T2: 1.1-1.5, T1: 4.1
33	Effect of part symmetry on handling time,	CO5	T2: 1.1-1.5, T1: 4.1
34	Effect of part thickness and size on handling time,	CO5	T2: 1.1-1.5, T1: 4.1
35	Effect of weight on handling time.	CO5	T2: 1.1-1.5, T1: 4.1
36	Parts requiring two hands for manipulation	CO5	T2: 1.1-1.5, T1: 4.1

37	Effects of combinations of factors.	CO6	T2: 1.1-1.5, T1: 4.1
38	Effect of symmetry effect of chamfer design on insertion operations	CO6	T2: 1.1-1.5, T1: 4.1
39	Case study on design of manual assembly.	CO6	T2: 1.1-1.5, T1: 4.1
40	Estimation of insertion time.	CO6	T2: 1.1-1.5, T1: 4.1
PROBLEM SOLVING/ CASE STUDIES			
1	Re-Design on Vehicle Front Support Structure Using DFMA.	CO 1	R2:7.5
2	The material of a solid cylindrical tie rod of cross-sectional area "A" and length "L" is to be selected for carrying a tensile load "P" with factor of safety "S". Explain the process of material selection as per the cost per unit property method.	CO 2	R2:7.5
3	Redesign of Forklift Hydraulic Cylinders using DFMA.	CO 2	R2:7.5
4	Case study in the form design, simple problems in the form design.	CO 2	R2:7.5
5	Selection of Material for an efficient flywheel	CO 2	R2:7.5
6	Selection of material of Spars for man-powered plane	CO 3	R2:7.5
7	Selection of forming of fan for vacuum cleaners	CO 3	R2:7.5
8	Crevice free Tube to Tube sheet welds in Waste Heat Boiler.	CO 3	R2:7.5
9	A batch of 15 cm diameter disks with a thickness of 4 mm are to be molded from acrylonitrile-butadiene-styrene (ABS) in a six-cavity mold. Determine the appropriate machine size.	CO 3	R2:7.5
10	For the 15 cm diameter disks molded in a six-cavity mold, described in Sec. 8.6, the required shot size is 489 cm3 . The recommended injection pressure for ABS is 1000 bars, or 100 MN/m2 . The available power at the injection unit of the 8500kN machine is 90 kW.	CO 4	R2:7.5
11	A sheet metal blank is 200mm long by 150mm wide and has plain semicircular ends with radius 75 mm; It is proposed that 500,000 parts should be manufactured using 16 gauge low carbon steel.	CO 4	R2:7.5
12	A set of only five measuring instruments is to be produced. A DFA analysis shows an estimated assembly time given by TA. Using a 90curve, provide an estimate for the average time to build the first two units. Use this value to determine the average time to assemble the next three units. Assume that the DFA time estimate would apply well for the average assembly time of 100 units	CO 5	R2:7.5
13	Case study on design on lever arch file mechanics.	CO 5	R2:7.5
14	Case study on designing of disposal of valve.	CO 6	R2:7.5
15	Tolerance stack, effects of assembly.	CO 6	R2:7.5

DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Definitions and Terminology of design for manufacturing.	CO 1	R4:2.1
2	Definitions and Terminology of machining and moulding.	CO 2	R4:2.1
3	Definitions and Terminology of design for metal cutting and metal joining.	CO 3,4	R4:2.1
4	Definitions and Terminology of development of assembly process.	CO 5	R4:2.1
5	Definitions and Terminology of design of manual assembly.	CO 6	R4:2.1
DISCUSSION OF QUESTION BANK			
1	Discussion on question bank of design for manufacturing.	CO 1	R4:2.1
2	Discussion on question bank of machining and moulding.	CO 2	T4:7.3
3	Discussion on question bank of design for metal cutting and metal joining.	CO 3,4	R4:5.1
4	Discussion on question bank of development of assembly process.	CO 5	T1:7.5
5	Discussion on question bank of design of manual assembly.	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,ME**
Mr.B.VijayaKrishna, Assistant Professor.

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Mechanical Engineering**				
Course Title	**Instrumentation and Control Systems**				
Course Code	AMEC39				
Program	B.Tech				
Semester	VII				
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	3	1.5
Course Coordinator	Mr. M. Sunil Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC19	IV	Machine Tools and Metrology
B.Tech	AMEC12	II	Fluid Mechanics and Hydraulic Machines

II COURSE OVERVIEW:

The Present course concentrates on developing basic understanding about various instruments that are involved in measuring. This course enables the student to understand the working of various measuring instruments. The course focuses on all principles, working, advantages, disadvantages and applications of various measuring instruments. In this course; students also will gain a broad understanding of the control systems. Student can learn in detail about how to measure displacement, temperature, pressure, level, flow, acceleration, vibration, strain, humidity, force, torque and power and their appropriate application.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Instrumentation and Control Systems	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
✓	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), and 10 marks for Alternative Assessment Tool (AAT).

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with

"either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
50%	Understand
50%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
	Continuous Internal Examination – 2 (Mid-term)	10	
	AAT-1	5	
	AAT-2	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			100

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

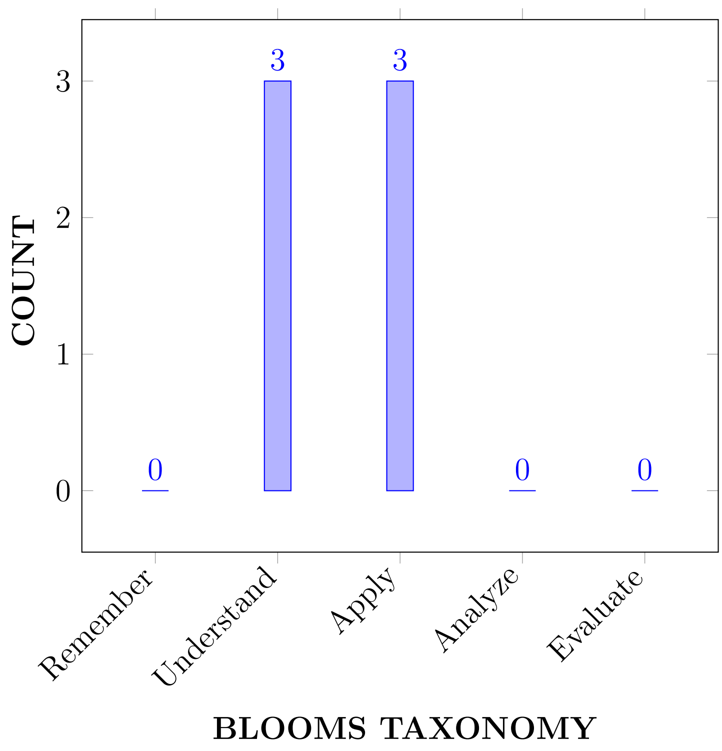
I	The fundamental knowledge of measuring principles, configuration and functional description of instruments with static, dynamic inputs and error control.
II	The concepts and working of instrumentation devices for displacement, flow, dynamic and other mechanical measurement applications.
III	Instrumentation practices and automatic control system for monitoring industrial real time processes within limits of parameter specifications.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Illustrate** the importance of basic principles, configuration and functional description of measuring instruments performance characteristics of an instrument when the device is exposed to measure dynamic inputs and error control	Understand
CO 2	**Identify** the measuring instruments based on the principle of working with the physical parameters such as displacement, temperature and pressure.	Apply
CO 3	**Make use of** appropriate instrument for measuring Speed, Acceleration and Vibration by considering different aspects.	Understand
CO 4	**Apply** relevant control systems for speed, position and control processes in practical applications.	Apply
CO 5	**Choose** the concepts for measurement of Stress, Strain, Humidity and their application for finding stress, strain, and humidity.	Apply
CO 6	**Describe** the control systems for temperature, speed and position control systems to industrial applications.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety and the cultural, societal, and Environmental considerations.	1	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	2	AAT

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-	✓	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	✓	-		-	-	-	-	-	-		-	✓	-
CO 5	✓	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	-	-		-	-	-	-	-	-	-	-	-	

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recognize (knowledge) the importance of basic principles, configuration, appreciate (understanding) their importance and applicability (apply) in solving (complex) engineering problems of measurement by applying the **scientific principles of mathematics and science.**	2
	PSO 2	Make use of **computational** and **experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 2	PO 1	Demonstrate (understand) performance characteristics of an instrument when the device is exposed to measure dynamic inputs and error control systems by applying the principles of **mathematics and engineering fundamentals.**	2
	PO 2	Analyze the performance parameters of meaasurements using **first principles of Mathematics and engineering sciences.**	2
CO 3	PO 1	Categorize (understand) the measuring instruments based on the principles of working with the physical parameters such as displacement, temperature and pressure etc., in solving (complex) fluid flow engineering problems by applying the principles of mathematics, science and engineering fundamentals. **mathematics, science and engineering fundamentals.**	3
	PO 2	Analyze the performance parameters of meaasurements using **first principles of Mathematics and engineering sciences.**	2
	PO 3	Design solutions for the measuring of vibration using **principles of Mathematics and engineering sciences.**	2
CO 4	PO 1	Explain (understand) calibration of instrument for measurement of all types of mechanical parameters by applying the principles of mathematics, science and engineering fundamentals. (**mathematics, science and engineering fundamentals.**)	3
	PO 2	Understand the given **problem statement** and **formulate** (complex) engineering problems and choosing appropriate measuring device for calibration considering mechanical parameter and substantiate with **interpretation** of variation in the **results**.	4
	PO 3	Understand the given **problem statement** and formulate (complex) engineering problems and choosing appropriate control systems **interpretation** of variation in the results.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 2	Make use of **computational** and **experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 5	PO 1	Demonstrate (understand) working principle of level measuring device for ascertaining parameter such as liquid level , in solving (complex) liquid level engineering problems by applying the applying the principles of **mathematics, science** and **engineering fundamentals** for controlling fluid level in industrial applications.	3
	PO 2	Understand the given **problem statement** and **formulate** (complex) fluid level engineering phenomena for deriving related equations from the provided **information and substantiate** with **interpretation** of variations in the results.	4
	PO 3	Understand the given **problem statement** and **formulate** (complex) concept for measurement of stress and strain for engineering application for information and substantiate with interpretation of variations in the results.	2
CO 6	PO 1	Explain (understand) the theory, phenomena and working of flow measuring instruments to solution of flow engineering problem by applying the principles of **mathematics**, **science** and **engineering fundamentals** to perform calibration for flow measuring devices.	3
	PO 2	Understand the given **problem statement** and **formulate**(complex) fluid flow engineering phenomena for deriving related equations from the provided information and substantiate with **interpretation** of variations in the **results**.	4

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	-	-	-	-	-		-	2	-
CO 2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	4	2	-	-	-	-	-	-	-	-		-	2	-
CO 5	3	4	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	4	-	-	-	-	-	-	-	-	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	-	-	-	-	-	-	-	-	-	-		-	100	-
CO 2	66.7	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	20	20	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	40	20	-	-	-	-	-	-	-	-		-	100	-
CO 5	100	40	20	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	40	-	-	-	-	-	-	-	-	-		-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation
1 -5% <C$\leq$ 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-		-	3	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	1	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	1	-	-	-	-	-	-	-	-		-	3	-
CO 5	3	1	1	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	1	-	-	-	-	-	-	-	-	-		-	-	-
TOTAL	18	5	3	-	-		-	-	-	-	-	-	-	6	-
AVERAGE	3	1	1	-	-	-	-	-	-	-	-	-	-	3	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	✓
Assignments	-	-	-	-	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE-I	**PRINCIPLES OF MEASUREMENT**
	Definition, basic principles of measurement, measurement systems, generalized configuration and functional descriptions of measuring instruments examples, dynamic performance characteristics, sources of error, classification and elimination of error.
MODULE-II	**MEASUREMENT OF DISPLACEMENT, TEMPERATURE, PRESSURE**
	Measurement of Displacement: Theory and construction of various transducers to measure displacement, peizo electric, inductive, capacitance, resistance, ionization and Photo electric transducers, Calibration procedures; Measurement of temperature: Classification ranges, various principles of measurement, expansion, electrical resistance, thermistor, thermocouple, pyrometers, temperature indicators; Measurement of pressure: classification, different principles used, manometers, piston, bourdon pressure gauges, bellows, diaphragm gauges. low pressure measurement, thermal conductivity gauges, ionization pressure gauges, Mcleod pressure gauge.
MODULE-III	**MEASUREMENT OF LEVEL, FLOW, SPEED, ACCELERATION AND VIBRATION**
	Measurement of Level: Direct method, indirect methods, capacitative, ultrasonic, magnetic, cryogenic fuel level indicators, bubler level indicators; Flow measurement: Rotameter, magnetic, ultrasonic, turbine flow meter, hot-wire anemometer, laser doppler anemometer (LDA); Measurement of Speed: Mechanical tachometers, electrical tachometers, stroboscope, noncontact type of tachometer; Measurement of Acceleration and Vibration: Different simple instruments, principles of seismic instruments, vibrometer and accelerometer using this principle.
MODULE-IV	**MEASUREMENT OF STRESS – STRAIN, HUMIDITY, FORCE, TORQUE AND POWER**
	Stress Strain Measurements: Various types of stress and strain measurements, electrical strain gauge, gauge factor method of usage of resistance strain gauge for bending compressive and tensile strains, usage for measuring torque, strain gauge rosette; Measurement of Humidity: Moisture content of gases, sling psychrometer, Absorption psychrometer, Dew point meter; Measurement of Force, Torque and Power:Elastic force meters, load cells, torsion meters, dynamometers
MODULE-V	**ELEMENTS OF CONTROL SYSTEMS**
	Elements of Control Systems: Introduction, importance, classification, open and closed systems, servomechanisms examples with block diagrams, temperature, speed and position control systems.

TEXTBOOKS

1. K.Padma Raju, Y J Reddy, “Instrumentation and Control Systems”, McGraw Hill Education, 1st Edition, 2016.

2. S.W.Bolton,“Instrumentation and Control Systems”, Newness Publisher,1st Edition, 2004.

3. K.Singh, “Industrial Instrumentation and Control”, McGraw Hill Education, 3rd Edition, 2015.

REFERENCE BOOKS:

1. D.S Kumar, " Measurement Systems, Applications and Design ", Anuradha agencies , 4th Edition, 2016.
2. B.C Nakra, K.K Choudary, "Instrumentation , measurement and analysis" , McGraw Hill Education 3rd Edition, 2010.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112/103/112103261/
2. https://nptel.ac.in/courses/108/105/108105064/

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=pages/mech-btech-course-syllabi-ug20

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Introduction to Outcome Based Education	-	-
CONTENT DELIVERY (THEORY)			
2	Introduction, definition, fundamental measuring process.	CO 1	T1: 1.1-1.16
3	Basic principles of measurement, classification, measurement systems.	CO 1	T1: 1.1-1.16
4	generalized configuration and functional descriptions of measuring instruments – examples	CO 1	T2:26.7
5	Static performance characteristics.	CO 1	T1: 1.16,
6	Dynamic performance characteristics.	CO 1	T1: 1.16,
7	Sources of error, Classification of errors.	CO 1	T1: 1.16
8	Classification of errors, elimination of error and calibration.	CO 1	T1: 1.16
9	Zero order, 1st order 2nd order systems.	CO 1	T1: 1.12-1.16
10	Classification of transducers, Theory and construction of LVDT, Resistance, Inductive transducer for measurement of displacement.	CO 2	T1: 14.1-14.2
11	Theory and construction of capacitance transducer for measurement of displacement.	CO 2	T1: 14.1-14.2
12	Theory and construction of Piezo electric and photo electric transducer transducers for measurement of displacement.	CO 2	T1: 14.1-14.2
13	Theory and construction of Ionization and Photo electric transducer for measurement of displacement.	CO 2	T1: 14.1-14.2
14	Hall effect Transducer, LDR.	CO 2	T1: 14.1-14.2
15	Measurement of Temperature: Classification – Ranges.	CO 2	T1: 20.1-20.3

16	Various principles of measurement – Expansion, Electrical Resistance	CO 3	T1: 20.1-20.3
17	Resistance Temperature Detyector (RTD).	CO 3	T1: 20.1-20.3
18	Thermistor for temperature measurement.	CO 3	T1: 20.1-20.3
19	Thermocouple for temperature measurement.	CO 3	T1: 20.1-20.3
20	Pyrometers – Temperature Indicators.	CO 3	T1: 20.1-20.3
21	Measurement of Pressure: Units – classification – different principles used.	CO 4	T1: 18.1-18.3
22	Piston gauge, Manometers.	CO 4	T1: 18.1-18.3
23	Bourdon pressure gauges, Bellows – Diaphragm gauges. Low pressure measurement.	CO 3	T1: 18.1-18.3
24	Thermal conductivity gauges.	CO 3	T1: 18.1-18.3
25	Ionization pressure gauges, Mcleod pressure gauge	CO 3	R2:7.5
26	Measurement of Level: Direct method – Indirect methods	CO 3	T1: 24.1-24.2
27	Capacitive, ultrasonic level measurement.	CO 3	T1: 24.1-24.2
28	Magnetic, cryogenic fuel level indicator.	CO 3	T1: 24.1-24.2
29	Bubbler level indicatorss	CO 3	T1: 24.1-24.2
30	Flow Measurement: Rotameter, magnetic flow meter	CO 3	R2:7.5
31	Ultrasonic, Turbine flow meter	CO 3	T1: 21.1-21.2
32	Hot–wire anemometer, Laser Doppler Anemometer (LDA)	CO 3	R2:7.5
33	Measurement of Speed: Mechanical Tachometers	CO 4	R2:7.5
34	Electrical tachometers	CO 4	R2:7.5
35	Noncontact type of tachometer , Stroboscope.	CO 4	R2:7.5
36	Measurement of Acceleration and Vibration: Different simple instruments.	CO 4	R2:7.5
37	Principles of Seismic instruments, Vibrometer and accelerometer using this principle, Stress Strain Measurements: Various types of stress and strain measurements.	CO 4	R2:7.5
38	Electrical strain gauge, gauge factor method of usage of resistance strain gauge for bending compressive and tensile strains,	CO 4	R2:7.68

39	usage for measuring torque, Strain gauge Rosettes, Measurement of Humidity: Moisture content of gases, sling psychrometer, Measurement of Humidity: Moisture content of gases, sling psychrometer, Measurement of Force , and Elastic force meters, Measurement of Torque, load cells, Torsion meters, Measurement of Power, Dynamometers	CO 5	R2:7.68
40	Elements of Control Systems: Introduction, Importance, Classification.	CO 6	R2:7.5
PROBLEM SOLVING/ CASE STUDIES			
1	A case study on remote instrumentation of Vibration and temperature in bearing housings.	CO 3	R2:2.1
2	A case study on PID control in control system resistance, thermistor, thermocouple, pyrometers, temperature indicators;	CO 2	T2:7.3
3	A case study of characterstic of temperature sensor using thermocouple and RTD sesnsor.	CO 2	R2:5.1
4	Design of an Automated Vibration Monitoring System for Condition Based Maintenance of a Lathe Machine.	CO 4, CO3	T1:7.5
5	A case study for flow measurement using turbine flow meter.	CO 3	R2:7.5
6	A case study on strain gauge measurements on large post-tensioned concrete beams of a railway support structure	CO 4	R4:2.1
7	A case study on Vehicle speed measurement model for video-based systems.	CO 3	T4:7.3
8	A case study of the national humidity and moisture measurement system.	CO 4	R4:5.1
9	A rectangular rosette is mounted on a steel late having E=200Gn/m2 and Poisson's ratio is 0.3. The three strains measured are e1=72x10-6 , e2 = 120x10-6 , e3 = 248x10-6 calculate the principal strains and stresses, the maximum shear stress and orientation angle for principal axis.	CO5	T1:7.5
10	A rectangular rosette is mounted on a steel late having E=400Gn/m2 and Poisson's ratio is 0.6. The three strains measured are e1=72x10-6 , e2= 120x10-6 , e3 = 248x10-6 calculate the principal strains and stresses, the maximum shear stress and orientation angle for principal axis. .	CO 4	R2:7.5
11	Describe typical closed-loop control systems that can be used in order to control the temperature of water being heated by steam, and Draw the block diagram of the arrangement and mention the use of feed back in application	CO 6	R4:2.1
12	Design and Implementation of steam control in steam power plant using Programmable Logic Controller	CO 6	T4:7.3
13	Comparing portable pyrometer performance with traditional DIP thermocouples in the foundry.	CO 2	R4:5.1
14	A McLeod gauge having V = 200 cm3 and a capillary diameter of 2.0mm is used to measure the gas pressure. What will be the pressure of the gas corresponding to a capillary of 4 cm?	CO 3	T1:7.5
15	Design and Implementation of Intelligent Traffic Control System using Programmable Logic Controller	CO 6	R2:7.5

DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Module-I:Measuring instruments examples, dynamic performance characteristics	CO 1	R2:2.1
2	Module-II:Measurement of temperature: Classification ranges, various principles of measurement, expansion, electrical resistance, thermistor, thermocouple, pyrometers, temperature indicators;	CO 2	T1:7.3
3	Module-III: Measurement of Speed: Mechanical tachometers, electrical tachometers, stroboscope	CO 3	R2:5.1
4	Module-IV:Measurement of Humidity: Moisture content of gases, sling psychrometer.	CO 4, CO 5	T1:7.5
5	Module-V:Elements of Control Systems: Introduction, Importance, Classification.	CO 6	R2:7.5
DISCUSSION OF QUESTION BANK			
1	Module-I:Measuring instruments examples, dynamic performance characteristics	CO 1	R1:2.1
2	Module-II:Measurement of temperature: Classification ranges, various principles of measurement, expansion, electrical resistance, thermistor, thermocouple, pyrometers, temperature indicators;	CO 2	T2:7.3
3	Module-III: Measurement of Speed: Mechanical tachometers, electrical tachometers, stroboscope	CO 3	R1:5.1
4	Module-IV:Measurement of Humidity: Moisture content of gases, sling psychrometer.	CO 4	T1:7.5
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Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**AUTOMOBILE ENGINEERING**				
Course Code	AMEC44				
Program	B.Tech				
Semester	VII				
Course Type	ELECTIVE				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. G. Sarat Raju, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AMEC14	IV	Applied Thermodynamics	4
UG	AMEC10	IV	Kinematics of Machinery	4

II COURSE OVERVIEW:

This course introduces structural and operational details of automobile and its systems. Major systems that contribute in the functioning of automobile which include fuel supply, cooling, ignition, electrical, transmission, suspension, braking and steering. Introduction of S.I and C.I engines which will work on Otto and Diesel cycles. The advanced ignition, braking and transmission systems are discussed. Also Focuses the alternative fuels for sustainable environment and low emission of the HC's and NOx to protect the global environment and reduces the possibility of minimizing the ozone layer depletion.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Heat Transfer	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	x	Chalk & Talk	✓	Assignments	x	MOOC
✓	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination..

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question. The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
70%	Understand
10%	Apply
10%	Analyze
0%	Evaluate
0%	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
	Continuous Internal Examination – 2 (Mid-term)	10	
	AAT-1	5	
	AAT-2	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			100

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Case study	Tech-talk	Complex problem solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

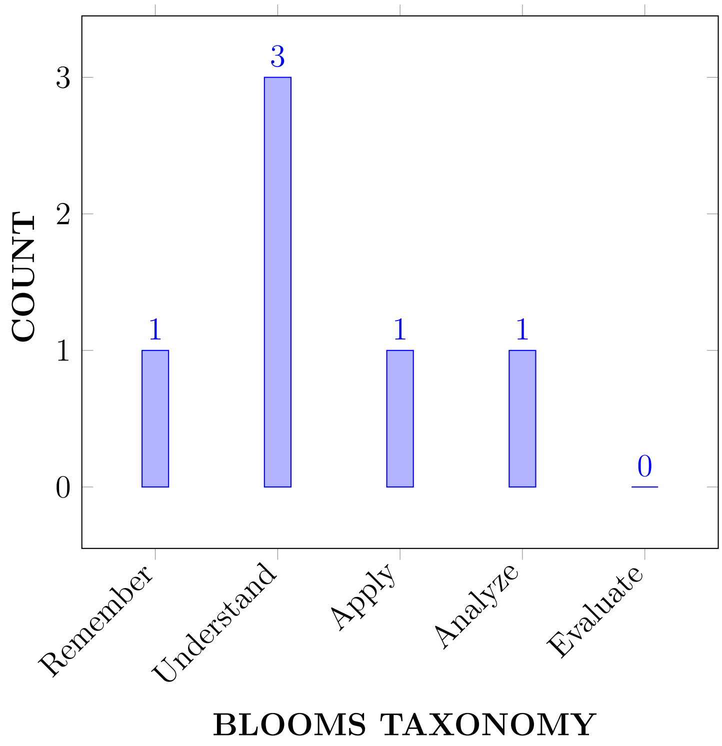
I	The need and scope of automobile engineering in the field of automotive industry.
II	The basic concepts and working principles of various automobile systems.
III	The mechanisms associated with the power transmission from engine to rear axles by using the concepts of kinematics of machines.
IV	The automobile emissions and preventive measures according to the national and international standards.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Identify** the basic components of automobile and working principles Of fuel injection systems to meet the load demands.	Remember
CO 2	**Compare** the various ignition systems, electrical circuits and operation process of various types of cooling systems used in automobile.	Understand
CO 3	**Analyze** the power transmission through clutches, gears, propeller shafts, universal joints and differential gear boxes to achieve differential outputs.	Apply
CO 4	**Demonstrate** different suspension systems used in motor bikes, cars, trucks for effective travel under several load conditions.	Understand
CO 5	**Select** the correct braking system, steering mechanism by comparing various systems and mechanisms in order to run vehicle smoothly.	Understand
CO 6	**Choose** the suitable system and its technological developments for environmental friendly automobiles in the real world applications.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

Program Outcomes	
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/CIA
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	SEE/CIA
PO 7	**Individual and Teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	3	AAT
PO 12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	2	SEE/CIA

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 5	-	✓	-	-	-	-	-	-	-	-	-	✓	-	✓	-
CO 6	✓	-	-	-	-	-	-	-	-	-	-	✓	-	✓	-

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply knowledge of**science, engineering** fundamentals to understand the concept of fuel injection system and the working of principal of different fuel injection systems, in order to , **mathematically** relate the performance of various injection systems.	3
	PO 2	**Recognize** the basic components of automobile and **Understand** the function of each component and **interpret**	3
CO 2	PO 1	Identify (knowledge) suitable mechanisms for cooling systems by using **mathematical principles** and **engineering fundamentals.**	2
	PO 2	**Recognize** the basic components of cooling systems and **Understand** the function of each component and **interpret** which **design** is appropriate.	4
CO 3	PO 2	Make use of the concept of Power transmission for the **Design, Model Creation** and **Validation** of **experimental design** of Power transmission by Problem Analysis	4

	PSO 2	Formulate and evaluate concepts of thermo-fluid systems to **provide solutions** for inter disciplinary **engineering applications** for sustainable designs forgears.	2
CO 4	PO 1	Recall (knowledge) the principles associated with suspension systems used in automobiles **scientific principles** of Methodology, **mathematical principles** and **engineering fundamentals.**	3
	PO 7	**Identify** the pollution control methods to **apply** the national and international standard	3
CO 5	PO 2	problem analysis based on first**principles of mathematics** and **engineering sciences** is essential to analyze complex engineering problems based on **data collection** which is related to steering mechanisms **validating** the **experimental design solution**	5
	PO12	problem analysis based on first**principles of mathematics** and **engineering sciences** is essential to analyze complex engineering problems based on **data collection** which is related to develop new mechanisms for engines **validating** the **experimental design solution**	5
	PSO 2	Formulate and evaluate concepts of thermo-fluid systems to **provide solutions** for inter disciplinary **engineering applications** for sustainable designs for brakes.	2
CO 6	PO 1	Recall (knowledge) the principles associated with brake systems used in automobiles **scientific principles** of Methodology, **mathematical principles** and **engineering fundamentals.**	3
	PO12	problem analysis based on first**principles of mathematics** and **engineering sciences** is essential to analyze complex engineering problems based on **data collection** which is related to develop new mechanisms for engines **validating** the **experimental design solution**	5
	PSO 2	Formulate and evaluate concepts of thermo-fluid systems to **provide solutions** for inter disciplinary **engineering applications** for sustainable designs inAutomobiles.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	Program Outcomes/ No. of Key Competencies Matched											PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	3	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-

CO 3	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	3	-	-	-	-		-	-	-
CO 5	-	5	-	-	-	-	-	-	-	-	-	5	-	2	-
CO 6	3	-	-	-	-	-	-	-	-	-	-	5	-	2	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	100	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.7	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	-	-	-	-	-	66.6	-	-	-	-		-	-	-
CO 5	-	66.6	-	-	-	-	-	-	-	-	-	50	-	100	-
CO 6	50	-	-	-	-	-	-	-	-	-	-	50	-	100	-

XV COURSE ARTICULATION MATRIX (CO –PO/ PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - 0$\leq$ C$\leq$ 5% – No correlation
2 - 40 % <C < 60% –Moderate
1-5 <C$\leq$ 40% – Low/ Slight
3 - 60% $\leq$ C < 100% – Substantial /High

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	3	-	-	-	-		-	-	-
CO 5	-	3	-	-	-	-	-	-	-	-	-	3	-	3	-
CO 6	2	-	-	-	-	-	-	-	-	-	-	2	-	3	-
TOTAL	11	6	3	1	-	4	9	-	-	-	-	-	-	9	-
AVERAGE	3	2	1	1	-	2	3	-	-	-	-	-	-	3	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

X	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION**
	Introduction to automobile engineering,chassis and body components,types of automobile engines,engine lubrication, engine servicing; Fuel system; spark ignition engine fuel supply systems, mechanical and electrical fuel pump, filters, carburetor types, air filters, petrol injection, multi-point fuel injection(MPFI) and gasoline direct injection systems; Compression ignition engines fuel supply systems, requirement of diesel injection systems,types of injection systems,direct injection systems,indirect injection(IDI)systems,fuel pump nozzle, spray formation, injection timing, testing of fuel pumps, CRDI and turbocharged direct injection (TDI) systems.
MODULE II	**COOLING SYSTEM**
	cooling requirements, air cooling, water cooling, , water and forced circulation system, radiators types ,cooling fan,water pump,thermostat,pressure sealed cooling,antifreeze solutions,intelligent cooling; Ignition system: Function of an ignition system, battery ignition system constructional features of storage, battery,contact breaker points,condenser and spark plug,magneto coil ignition system,electronic ignition system using contact breaker, electronic ignition using contact triggers, spark advance and retard mechanism; Electrical system: Charging circuit, generator, current-voltage regulator, starting system, bendix drive mechanism solenoid switch, lighting systems, automatic high beam control, horn, wiper, fuel gauge, oil pressure gauge, engine temperature indicator.
MODULE III	**TRANSMISSION AND SUSPENSIONS SYSTEMS**
	Transmission system: Clutches, principle, types, cone clutch, single plate clutch, multi plate clutch, magnetic and centrifugal clutches, fluid flywheel, gear box, types, sliding mesh, constant mesh, synchro mesh gear boxes, epi cyclic gear box, auto transmission, continuous variable transmission over drive, torque converter, propeller shaft, Hotch-Kiss drive, torque tube drive, universal joint, differential, rear axles, types, wheels and tires. Suspension system: Objects of suspension systems, rigid axle suspension system, torsion bar, shock absorber, independent suspension system, air suspension system, Daimler-benz vehicle suspension.
MODULE IV	**BRAKING AND STEERING SYSTEMS**
	Braking system: Mechanical brake system, Hydraulic brakes system, Master cylinder, wheel cylinder tandem master cylinder; Requirement of brake fluid, Pneumatic and vacuum brake, anti-skid braking (ABS), regenerative braking; Steering system: Steering geometry, camber, castor, king pin, rake, combined angle, toe-in, toe-out, center point steering, types of steering mechanism, power steering, Hydraulic, electronics, Ackerman steering mechanism, Davis steering mechanism, steering gears types, steering linkages, special steering columns.

MODULE V	**EMISSIONS FROM AUTOMOBILES**
	Emissions from Automobiles, Pollution standards national and international, various pollution control techniques: Multipoint fuel injection for spark ignition engines, common rail diesel injection, variable valve timing, closed crank cake ventilation, pc valves, EGR value, catalytic converters, catalyst window, lambda probe, energy alternatives, solar, photo-voltaic, hydrogen, biomass, alcohols, LPG, CNG, liquid Fuels and gaseous fuels, hydrogen as a fuel for internal combustion engines, their merits and demerits, standard vehicle maintenance practice.

TEXTBOOKS

1. WillamH Crouse,DonaldL. Angling, —AutomobileEngineering‖,McGraw-Hill,10th Edition,2006.
2. Manzoor, NawazishMehdi, YosufAli, —A Text Book Automobile Engineering‖, Frontline Publications, 1st Edition,2008.
3. 3. Dr.KirpalSingh,—AutomobileEngineering‖,StandardPublishers‖,2nd Edition,2013.

REFERENCE BOOKS:

1. R.K.Rajput,—ATextBookofAutomobileEngineering‖,LaxmiPublications,1stEdition,2010.
2. S. Srinivasan,—AutomotiveEngines‖,McGraw-Hill,2nd Edition,2003.
3. Khalil U Siddiqui, —A Text Book of Automobile Engineering‖, New Age International, 1stEdition, 2009.

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Discussion on OBE to equip the learning skills of students		
CONTENT DELIVERY (THEORY)			
1	Introduction: Resistance to vehicle motion Layout of automobile Chassis and body components	CO 1	T2:2.3
2	Types of automobile engines	CO 1	R1:2.6
3	Engine lubrication, Engine Servicing	CO 1	T1:2.6
4	Engine lubrication, Engine Servicing	CO 1	T1:2.6
5	Fuel System in S.I Engines mechanical and electrical, Fuel filters.	CO 1	T2:2.7, R1:2.18
6	Carburetor, Air filters	CO 1	T2:2.22
7	Petrol injection, MPFI and GDI Systems	CO 1	T2:2.25
8	C.I Engines: Diesel injection systems	CO 1	T2:2.25
9	Types of injection systems, DI systems IDI systems, Fuel pump, Nozzle, spray formation	CO 2	T2:2.25

10	Injection timing, testing of fuel pumps, CRDI and TDI systems	CO 1	T2:2.26 R1:2.55
11	Cooling system: Cooling requirements, Air cooling, Liquid cooling, Thermo, Water and Forced circulation system	CO 2	T2:2.16 R1:2.61
12	Thermo, Water and Forced circulation system	CO 2	T2:2.16 R1:2.61
13	Radiators, cooling fan, water pump	CO 2	T2:2.16 R1:2.61
14	Thermostat, evaporative cooling-pressure sealed cooling-antifreeze solutions	CO 2	T2:2.30 R1:2.58
15	Ignition System: Function of an ignition system, battery ignition system	CO 2	T2:2.30 R1:2.58
16	Storage batteries, auto transformer, contact breaker points.	CO 2	T2:2.30 R1:2.58
17	Condenser and spark plug-Magneto coil ignition system.	CO 3	T2:2.30 R1:2.58
18	Electronic ignition system using contact breaker	CO 3	T2:3.14 R1:4.31
19	Electronic ignition using contact triggers	CO 3	T2:3.14 R1:4.31
20	Spark advance and retard mechanism.	CO 3	T2:3.14 R1:4.33
21	Electrical System: Charging circuit, Generator	CO 3	R1:4.36
22	Current voltage regulator	CO 3	R1:4.36
23	Starting system, bendix drive mechanism	CO 4	T2:3.18 R1:4.64
24	Solenoid switch, lighting systems, Horn, wiper, fuel gauge	CO 4	T2:3.18 R1:4.64
25	Oil pressure gauge, engine temperature indicator	CO 4	T2:3.22 R1:4.67
26	Transmission system: Clutches, principle, types, cone clutch	CO 4	T2:3.22 R1:4.67
27	Transmission system: Clutches, principle, types, cone clutch	CO 4	T2:3.22 R1:4.67
28	Single plate clutch, Multi plate clutch, Magnetic and centrifugal clutches	CO 4	T2:3.28 R1:4.67
29	Fluid fly wheel-gear boxes,Sliding mesh, constant mesh, synchromesh gear boxes	CO 5	T2:4.2 R1:4.67
30	Epi-cyclic gear box Over drive torque converter	CO 5	T2:4.3 R1:4.71
31	Propeller shaft-Hotch kiss drive.	CO 5	T1:4.8 R2:4.68
32	Torque tube drive	CO 5	T2:4.15 R1:5.74
33	Propeller shaft-Hotch kiss drive.	CO 5	T1:4.12 R2:5.75
34	Torque tube drive, Hotch kiss drive, Torque tube drive Comparison	CO 5	T1:4.8 R2:5.72

35	Wheels Construction,Types ,Tires Construction,Types	CO 5	T1:5.8 R1:5.73
36	Objects of suspension systems-rigid axle suspension system	CO 5	T1:5.14 R1:6.78
37	Torsion bar ,Shock absorber	CO 6	T2:5.19 R1:6.81
38	Independent suspension system, air suspension system.Daimler-benz vehicle suspension.	CO 6	T1:6.4 R2:6.8
39	Braking system: Mechanical brake system Hydraulic brake system, Master cylinder ,Requirement of brake fluid.	CO 6	T2:7.7 R1:7.74
40	Pneumatic brakes Wheel cylinder anti-skid braking (ABS), regenerative braking;	CO 6	T1:7.12 R2:8.75
41	Steering geometry, camber, castor, king pin, rake, combined angle toe-in, toe-out	CO 6	T1:7.8 R1:8.72
42	center point steering, types of steering mechanism, power steering, Hydraulic, electronics.	CO 6	T1:8.8 R3:8.73
43	Ackerman steering mechanism, Davis steering mechanism, steering gears and steering linkages.	CO 6	T1:9.14 R1:10.78
44	Pollution standards National and international-pollution control techniques Multipoint fuel injection for SI Engines, Common rail diesel injection	CO 6	T2:9.19 R1:10.814
45	solar, photo-voltaic, hydrogen, biomass, alcohols, LPG, CNG, liquid Fuels and gaseous fuels , hydrogen as a fuel for internal combustion engines, their merits and demerits, standard vehicle maintenance practice.	CO 6	T1:10.4 R2:11.68
CASE STUDIES			
1	what are the reasons for Diesel Fuel Contamination in Fleet Vehicles	CO 1	T2: 1.1-1.5, T1: 4.1
2	Why Fuel Tank Ventilation System Failure	CO 1	R1: 1.1-1.5, T2 : 4.1
3	How Direct Injection System Efficiency can be Improved	CO 1	T1: 1.1-1.5, T2 : 4.1
4	Direct Injection System (DIS) vs. Indirect Injection System (IDI) - Fuel Efficiency and Emissions	CO 2	R2: 1.1-1.5, T1: 4.1
5	Overheating Issues in a Passenger Car.	CO 2	T2: 1.1-1.5, T1: 4.1
7	Analysis of a Current-Voltage Regulator and Starting System with Bendix Drive Mechanism Solenoid Switch	CO 3	T2: 1.1-1.5, T1: 4.1
8	The implementation and benefits of Automatic High Beam Control (AHBC) technology in modern vehicles.	CO 3	T2: 1.1-1.5, T1: 4.1

9	Horn and Wiper Control Case Study in Modern Vehicles	CO 3	R2: 1.1-1.5, T1: 4.1
10	Fluid Flywheel (Fluid Coupling) - Case Study	CO 4	T2: 1.1-1.5, T1: 4.1
11	Synchromesh Gearbox - Passenger Car Transmission	CO 4	R2: 1.1-1.5, T1: 4.1
12	Improving Vehicle Suspension Systems: A Case Study	CO 4	T2: 1.1-1.5, T1: 4.1
13	: Case Study - Automobile Braking System	CO 5, CO 6	T2: 1.1-1.5, T1: 4.1
14	Improving Handling Performance in a Sports Car	CO 5, CO 6	R2: 1.1-1.5, T1: 4.1
15	Comparison of LPG, CNG, Liquid Fuels, and Gaseous Fuels for Transportation	CO 5, CO 6	R2: 1.1-1.5, T1: 4.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Purpose of Crankcase, Crankcase actually acts like a sump housing crank, crankshaft, and connecting rod and is attached to cylinder. These are made of aluminium alloy, steel, cast iron etc. by casting process	CO 1	R3:2.1
2	Gudgeon Pin,It is the pin joining small end of the connecting rod and piston. This is made of steel by forging process.	CO 2	R3:2.1
3	What is Cetane Number? The cetane number refers to the ease with which diesel fuel ignites. A high cetane number means the fuel is fast burning and ignites easily at a relatively low temperature.	CO 3, CO 4	R3:2.1
4	What is the use of Thermostatic Radiator Valve?,A thermostatic radiator valve (TRV) is a self-regulating valve fitted to hot water heating system radiator, to control the temperature of a room by changing the flow of hot water to the radiator.	CO 5	R3:2.1
5	Twin Clutch transmission,A semi-automatic transmission system with double dry clutch, consisting of two gearboxes in parallel that allow the next gear to engage while the previous one is still engaged.	CO 6	R3:2.1
DISCUSSION OF QUESTION BANK			
1	Illustrate how turbocharged direct injection (TDI) systems improve engine performance.	CO 1	R3:2.1
2	Compare intelligent cooling with conventional cooling. How intelligent cooling systems improve engine performance?	CO 2	T2:7.3
3	Sketch and explain the construction and working of wishbone type independent front suspension.	CO 3,4	R3:5.1

4	Why drum type hydraulic brakes are so designed that there should be residual pressure in the brake lines even when the brakes are in the released position?	CO 5	T1:7.5
5	What happens when at higher speeds the crankcase Emissions exceed the flow rating of the PCV valve?	CO 6	T1: 4.1

Signature of Course Coordinator **HOD, ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**PRODUCTION PLANNING CONTROL**				
Course Code	AMEC56				
Program	B.Tech				
Semester	VIII				
Course Type	ELECTIVE				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr R.Srinivas, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	**Course Code**	**Semester**	**Prerequisites**
B.Tech	AMEB05	III	Manufacturing Process
B.Tech	AMEB16	V	Manufacturing Technology

II COURSE OVERVIEW:

Production planning and control refers two strategies that work cohesively throughout the manufacturing process. It involves what to produce, when to produce it, how much to produce, and more. Production system requires the optimal utilization of natural resources like man power, money, machine, materials and time. A long-term view of production planning is necessary to fully optimize the production flow based the utilization of resource allocation of activities of employees, materials and production capacity. to develop, manage and control all aspects of an effective and efficient manufacturing planning and control system- a key to the success of any product manufacturing company

III MARKS DISTRIBUTION:

Subject	**SEE Examination**	**CIE Examination**	**Total Marks**
Production Planning Control	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), and 10 marks for Alternative Assessment Tool (AAT).

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
16.6%	Remember
50%	Understand
0%	Apply
33.3 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

<table>
<tr><th colspan="2">Component</th><th>Marks</th><th>Total Marks</th></tr>
<tr><td rowspan="4">CIA</td><td>Continuous Internal Examination – 1 (Mid-term)</td><td>10</td><td rowspan="4">30</td></tr>
<tr><td>Continuous Internal Examination – 2 (Mid-term)</td><td>10</td></tr>
<tr><td>AAT-1</td><td>5</td></tr>
<tr><td>AAT-2</td><td>5</td></tr>
<tr><td>SEE</td><td>Semester End Examination (SEE)</td><td>70</td><td>70</td></tr>
<tr><td colspan="3">Total Marks</td><td>100</td></tr>
</table>

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

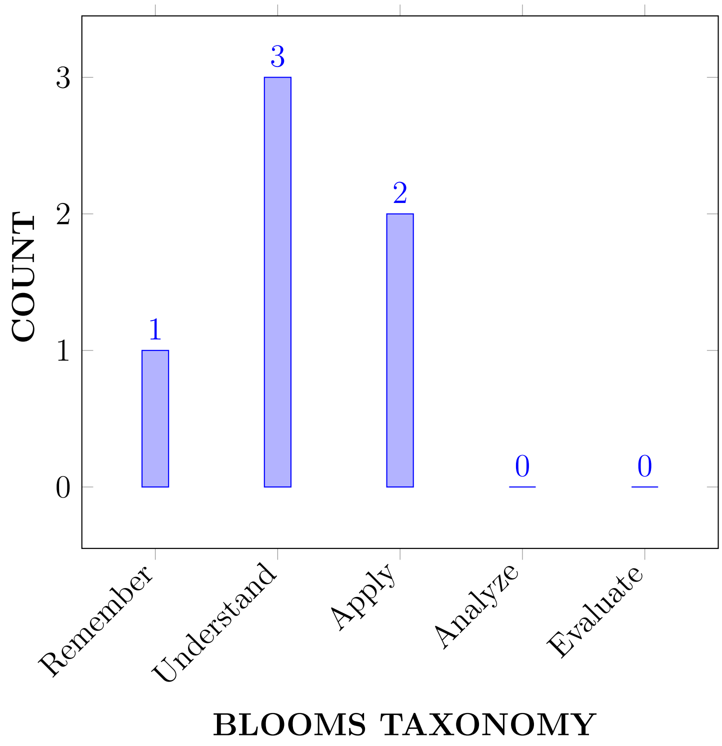
I	To develop, manage and control all aspects of an effective and efficient manufacturing planning and control system which is a key component to the success of any product manufacturing company.
II	The Methodology and models related to forecasting, business operations and productivity in supply chain management
III	The Strategies of capacity planning, materials requirements, inventory models,scheduling methods in various aspects of the manufacturing and service industry

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Define** different inventory methods in Production Planning that empower manufacturers to enhance smarter and optimized production process. Show the necessity and importance of expediting based on functionality, cost and time in development of business activity.	Remember
CO 2	**Classify** various Forecasting techniques (Qualitative & Quantities) to provide valuable inputs for number of planning decisions and continuous improvement.	Understand
CO 3	**Explain** different types of inventories and select the ordering quantity for minimizing the operation cost. Master Production Schedule and a resultant Materials Requirement Plan (MRP)for a complete production facility.	Understand
CO 4	**Identify** the forecasting models and errors associated with production to develop business enterprise for product demand, profits, sales, material requirements and the capacity planning process for business operations.	Apply
CO 5	**Make use of** the impact of production/inventory cost decisions and operations strategies on the break-even, return on investment and profit analysis of a business enterprise Apply forward and backward scheduling policies to analyze different job shop schedules with reference to prioty rules.	Apply
CO 6	**Summarize** production and inventory planning/control systems and scheduling techniques by using engineering techniques for a complete production facility. Make use of centralized and decentralized dispatching techniques forproduct delivery as per customer needs.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (Conduct Investigations of Complex Problems).
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations (Modern Tool Usage).
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/CIA
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	SEE/CIA
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	SEE/CIA
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	SEE/CIA
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	1	SEE/CIA
PSO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	1	SEE/CIA

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	2	Discussion /AAT
PSO 3	Make use of computational and experimental tools for building career paths towards innovative startups, employability and higher studies.	1	SEE/CIA

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	✓	-	-	-	-	-	-	-	✓	-	-	-	-
CO 2	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	✓	✓	-	-	-	-	-	-	-	-	✓	✓	-	✓
CO 5	-	✓	✓	-	-	-	-	-	-	-	✓	-	✓	-	-
CO 6	-	✓	-	-	-	✓	-	-	-	-	-	-	-	-	

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Define different inventory methods in Production Planning that empower manufacturers to enhance smarter and optimized production process by applying the **scientific principles** of **mathematics and science**	2
	PO 2	Understand the given **problem statement** and apply **data validation** techniques to solve (complex) **specific engineering problems** related to design	3
	PO 3	Forging techniques for the development of critical products for public **health and safety**, and the **cultural, societal** and **Environmental considerations**	3
	PO 11	Demonstrate knowledge and understanding ofEngineering and management principles and Apply these to ones own work, as a member and leader in a team, to Relate projects and in **multidisciplinary environments**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO 1	Recall (knowledge) different inventory methods in Production Planning that empower manufacturers to enhance smarter and optimized production process by applying the **scientific principles** of **mathematics and science**.	2
CO 3	PO 2	Understand the given **problem statement** and apply **data validation** techniques to solve (complex) **specific engineering problems** related to design	3
	PO 3	Forging techniques for the development of critical products for public **health and safety**, and the **cultural, societal** and **Environmental considerations**	3
CO 4	PO 2	Understand the given **problem statement** and apply **data validation** techniques to solve (complex) **specific engineering problems** related to design.	3
	PO 3	Forging techniques for the development of critical products for public **health and safety**, and the **cultural, societal** and **Environmental considerations**	3
	PO 12	Identify the need for and have the preparation and ability To take part in independent and **life- long learning** in the broadest context of **technological change**	2
	PSO 1	To Construct engineering professional capable of synthesizing and **analyzing mechanical systems** including allied engineering streams.	1
	PSO 3	Make use of **computational and experimental tools** forcreating innovative career paths, to be an entrepreneur and desire for **higher studies in the field of production planning and control**	2
CO 5	PO 2	Understand the given **problem statement** and apply **data validation** techniques to solve (complex) **specific engineering problems** related to design.	3
	PO 3	Forging techniques for the development of critical products for public **health and safety**, and the **cultural, societal** and **Environmental considerations**	3
	PO 11	Demonstrate knowledge and understanding of **Engineering and management principles** and Apply these to ones own work, as a member and leader in a team, to Relate projects and in **multidisciplinary environments.**	2
	PSO 1	To Construct engineering professional capable of synthesizing and **analyzing mechanical systems** including allied engineering streams	1
CO 6	PO 2	Understand the given **problem statement** and apply **data validation** techniques to solve (complex) **specific engineering problems** related to design.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 6	Apply reasoning informed by contextual knowledge to assess **societal, health, safety, legal and cultural issues** and the consequent responsibilities Classify the professional engineering practice.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	3	3	-	-	-	-	-	-	-	2	-	-	-	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	3	3	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	3	3	-		-	-	-	-	-	-	2	1	-	2
CO 5	-	3	3	-	-	-	-	-	-	-	2	-	1	-	-
CO 6	-	2	-	-	-	2	-	-	-	-	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66	30	30	-	-	-	-	-	-	-	16	-	-	-	-
CO 2	66	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	30	30	-		-	-	-	-	-	-	-	-	-	-
CO 4	-	30	30	-	-	-	-	-	-	-	-	16	50	-	100
CO 5	-	30	30	-		-	-	-	-	-	16	-	50	-	-
CO 6	-	20	-	-	-	20	-	-	-	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 - $5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	1	-	-	-	-	-	-	-	1	-	-	-	
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	1	1	-	-	-	-	-	-	-	-	1	2	-	3

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 5	-	1	1	-	-	-	-	-	-	-	1	-	2	-	-
CO 6	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-
TOTAL	6	5	4	-	-	1	-	-	-	-	2	1	4	-	3
AVERAGE	3	1	1	-	-	1	-	-	-	-	1	1	2	-	1

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**OVERVIEW OF PRODUCTION PLANNING CONTROL**
	Introduction: Definition, Objectives of production planning and control, functions of production planning and control, elements of production control, types of production, organization of production planning and control department, internal organization of department
MODULE II	**FORECASTING**
	Forecasting: Importance of forecasting, types of forecasting, their uses, general principles of forecasting, forecasting techniques, qualitative methods and quantitive methods; Inventorymanagement, functions of inventories relevant inventory costs ABC analysis, VED analysis, EOQ model, inventory control systems, P-Systems and Q-Systems.
MODULE III	**INTRODUCTION TO MRP**
	Introduction to MRP and ERP, LOB (Line of Balance), JIT inventory, and Japanese concepts. Routing, definition, routing procedure Route sheets, bill of material, factors affecting routing procedure, Schedule, definition, difference with loading.
MODULE IV	**SCHEDULING**
	Scheduling Policies, techniques, Standard scheduling methods; Line balancing, aggregate planning, chase planning, expediting, controlling aspects
MODULE V	**DESPATCHING**
	Dispatching: Activities of dispatcher, dispatching procedure, followup, definition, reason for existence of functions, types of followup, applications of computer in production planning and control.

TEXTBOOKS

1. Frank M. White, "PPC ", McGraw Hill Education Private Limited, 8th Edition, 2017 .

REFERENCE BOOKS:

1. Yuan S W, "Line production", Prentice-Hall, 2nd Edition, 1987.

WEB REFERENCES:

1. https://nptel.ac.in/courses/1526489/1

COURSE WEB PAGE:

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

OBE DISCUSSION			
S.No	Course Description on Outcome Based Education (OBE): Course Objectives, Course Ourcomes(CO), Program Outcomes(PO) and Co - PO Mapping	-	-
CONTENT DELIVERY (THEORY)			
S.No	**Topics to be covered**	**CO's**	**Reference T1: 4.1**
1	Introduction: Definition, Objectives of production planning and control	CO 1	T2:2.3
2	Functions of production planning and control, elements of production control	CO 1	T1:2.6
3	Types of production, organization of production planning and control	CO 1	T1:2.6
4	Department, internal organization of department.	CO 1	T2:2.7 R1:2.18
5	Forecasting: Importance of forecasting	CO 2	T2:2.22
6	Types of forecasting, their uses	CO 2	T2:2.25
7	General principles of forecasting	CO 2	T2:2.26 R1:2.55
8	All the factors affecting the Forecasting	CO 2	T2:1.51
9	Information required for production plannning	CO 2	T2:2.26
10	Qualitative methods and quantitive methods	CO 2	T2:3.56
11	Inventory management, functions of inventories relevant	CO 2	T2:2.81
12	inventory costs ABC analysis, VED analysis, EOQ model, inventory control systems,	CO 2	T2:3.96
13	PSystems and Q-Systems	CO 2	T2:2.16 R1:2.61
14	Introduction to MRP and ERP	CO 3	T2:2.30 R 1:2.58
15	LOB (Line of Balance), JIT inventory, and Japanese concepts.	CO 3	T2:3.6 R1:4.29
16	Routing, definition, routing procedure Route sheets	CO 3	T2:3.14 R1:4.31
17	Bill of material, factors affecting routing procedure	CO 3	T2:3.14 R1:4.33
18	Schedule, definition, difference with loading.	CO 3, CO 4	R1:4.36

19	Scheduling Policies	CO5	T2:3.18 R1:4.64
20	Techniques, Standard scheduling methods	CO 5	T2:3.12
21	Advantages and Limitation of scheduling methods	CO 5	T2:3.13
22	Line balancing	CO 5	T2:4.14
23	Aggregate planning	CO 5	T2:4.15
24	Chase planning, expediting, controlling aspects	CO 5	T2:5.16
25	Forecasting techniques, qualitative methods and quantitive Methods	CO 5	T2:3.22
26	Forecasting techniques, qualitative methods and quantitive methods	CO5	T2:3.28 R1:4.67
27	Inventory management, functions of inventories	CO 5	T2:4.2
28	Inventory management, functions of inventories	CO 3	T2:4.3 R1:4.71
29	Relevant inventory costs ABC analysis, VED analysis	CO 5	T1:4.8 R2:4.68
30	Relevant inventory costs ABC analysis, VED analysis	CO 5	T2:4.15 R1:5.74
31	Methods in line balancing and production out put control	CO 5	T2:7.18
32	concept of Just In Time manufacturing	CO 5	T2:6.19
33	Explaining Kaban and Pull sytem	CO 5	T2:9.20
34	Implimentation of ERP software in supply chain management	CO 6	T2:5.21
35	Dispatching: Activities of dispatcher	CO 6	T2:7.12
36	Dispatching procedure	CO 6	T1:4.12 R2:5.75
37	Follow up, definition, reason for existence of functions,	CO 6	T1:4.8 R1:5.72
38	Types of follow up	CO 6	T1:5.8 R1:5.73
39	Applications of computer in production planning and control.	CO 6	T1:5.14 R1:6.78
40	Activities,follow up incomputer in production planning and control	CO 6	T2:5.19 R1:6.81
PROBLEM SOLVING/ CASE STUDIES			
1	Calculating EOQ using ABC Analysis	CO 3	R2:7.5
2	Calculate Demand as per the previous years sales	CO 3	R2:4.5
3	Calculating XYZ using ABC Analysis	CO 3	R2:2.5
4	Calculate out put of production using program evalaute review technique	CO 3	R2:5.5
5	supply chain management calculations based on the routes	CO 6	R2:6.5
6	ERP, LOB (Line of Balance)	CO 3, CO 2	T1:6.4 R2:6.8
7	ERP, LOB (Line of Balance)	CO 2, CO4	T2:7.7 R1:7.74

8	JIT inventory, and Japanese concepts	CO 1, CO 5	T1:7.12 R2:8.75
9	JIT inventory, and Japanese concepts	CO 3, CO 2	T1:7.8 R1:8.72
10	Definition : Routing System	CO 3, CO 2	T1:8.8 R1:8.73
11	Routing procedure Route sheet	CO 6, CO 1	T1:9.14 R1:10.78
12	Listing the costs associated with inventories	CO 3, CO 4	T2:8.24
13	Inventory control models with shortges	CO 2, CO 5	T2:9.86
14	Estimation of dynamic demand inventory problems	CO 3, CO 4	T2:8.45
15	All EOQ problems with price break	CO 5, CO6	T2:6.75
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Overview of Production Planning Control	CO 1	R2:2.5
2	Forecasting in Production Planning Control	CO 2	R2:6.5
3	Introduction to MRP and Routing	CO 3, CO 4	R2:1.5
4	Scheduling in Production Planning Control	CO 5	R2:4.5
5	Dispatching in Production Planning Control	CO 6	R2:6.5
DISCUSSION OF QUESTION BANK			
1	Overview of Production Planning Control	CO 1	R4:1.1
2	Forecasting in Production Planning Control	CO 2	T4:5.3
3	Introduction to MRP and Routing	CO 3, CO 4	R4:6.1
4	Scheduling in Production Planning Contro	CO 5	T1:3.5
5	ispatching in Production Planning Control	CO 6	T1: 2.1

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**CAD/CAM**				
Course Code	AMEC38				
Program	B.Tech				
Semester	VII				
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr V.Mahidhar Reddy, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AMEB02	II	Engineering Graphics and Design Laboratory	4
UG	AMEB16	V	Manufacturing Technology	4

II COURSE OVERVIEW:

Computer aided Design/ Computer aided Manufacturing (CAD/CAM) is a course primary important to mechanical engineering students. The aim is to impart the overview of computer applications or design and manufacturing the discrete engine components, assemblies and final product to meet the global competition. The course covers the life cycle of a product describes the product model generation, analysis structural, thermal, dynamic behaviors. This course also deals with creation of synthetic curves and surfaces. It imposes the knowledge o latest manufacturing techniques using CNC/DNC Machines centers with different CNC programming methods, Manufacturing processes, Group Technologies. It makes the student to understand the modern inspection methods and concepts of CIM.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
CAD/CAM	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
✓	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination..

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question. The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
20%	Understand
70%	Apply
0%	Analyze
0%	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
	Continuous Internal Examination – 2 (Mid-term)	10	
	AAT-1	5	
	AAT-2	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			100

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

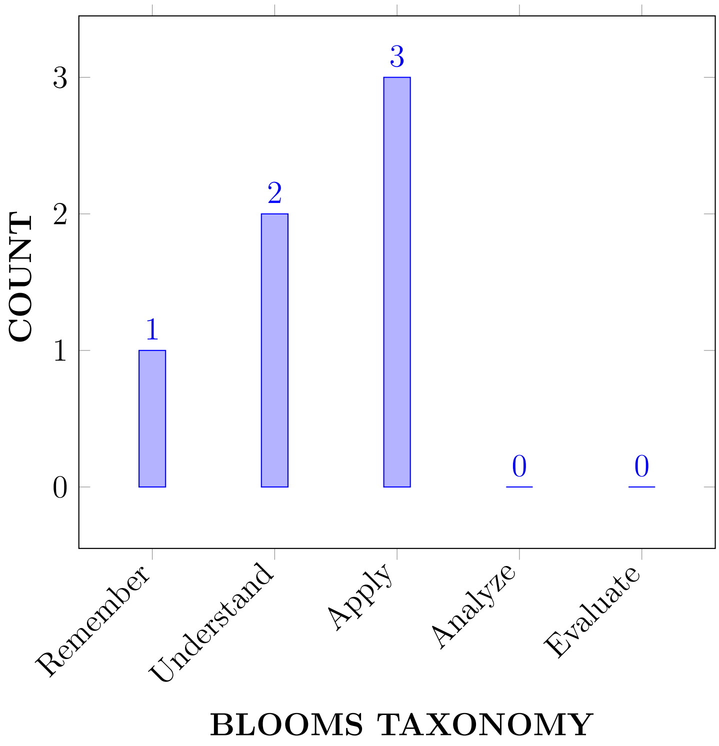
I	The product designs, manufacturing processes, and production plant as critical base for the interface and integration of CAD/CAM.
II	The assimilation of all product life cycle systems using computer controlled networks, integrated systems software and secondary information technologies.
III	Implementation of computer aided design techniques, digital in seamless way in the manufacturing automation for product life management systems.
IV	Identify the quality parameters by adopting the contact and non-contact type of inspection techniques.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Expalin** the integration of CAD, CAM and other systems with support of hardware and software for product life cycle management.	Understand
CO 2	**Make use of** geometric models, curve representation and surface representation to generate solid modelling.	Apply
CO 3	**Develop** NC part program data using manual data input (MDI) and automatically using standard commercial CAM package for manufacturing of required component using CNC milling or turning applications.	Apply
CO 4	**Compare** various computer controlled machine tools with respect to their functional capacity.	Understand
CO 5	**Chose** the different quality control methods and various contact and non-contact inspection methods used in various manufacturing systems.	Remember
CO 6	**Organize** the computer controlled monitoring and material handling management system for computer integrated manufacturing systems.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** : Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques,resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** : Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/CIA
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	SEE/CIA
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	SEE/CIA
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations.	2	Assignments/ Discussion
PO 12	**Life-Long Learning:**Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	Research paper analysis / Short term courses

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	3	SEE/CIA

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	-	-	-	-	-	-	-	-	-	-	✓	✓	-	-
CO 3	✓	-	✓	-	✓	-	-	-	-	-	-	✓	✓	-	-
CO 4	✓	✓	✓	-	-	-	-	-	-	-	-	✓	✓	-	
CO 5	✓	✓	-	-	✓	-	-	-	-	-	-	-	✓		-
CO 6	✓	✓	✓	-	-	-	-	-	-	-	-		✓	-	-

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Recollect (knowledge) the basic concept of static stability and to an extent appreciate (understand) the importance of longitudinal, lateral and directional modes of stability by applying the principles **scientific principles** of Methodology, **mathematical principles** and **engineering fundamentals.**	3
CO 2	PO 1	Describe (knowledge) in the field of computer aided design system and computer aided manufacturing **using computer graphics and synthetic entities using latest state of art technologies.** and **engineering fundamentals.**	3
	PO 12	Make use of experimental tools for innovation to **assess high speed machining and rapid prototyping.**	2
	PSO 1	Extend the focus to understand the **fundamental knowledge of digital manufacturing and limitations of Modern Tool**	3
CO 3	PO 1	**Analyse complex mechanical designs usage** and geometrical modelling techniques and PLM software's.	3
	PO 3	Identify (knowledge) to compare NC/CNC machines with interpolations accuracy and their functions and applications with the **fundamentals of mathematics, science, and engineering fundamentals**	2

	PO 5	**Use the mathematical model** to justify ABC Analysis and economic order quantities in manufacturing planning.	2
	PO 12	Use the retrieval and generative type process plans to minimize the ideal time to **Use the retrieval and generative type process plans to minimize the ideal time to**	2
	PSO 1	**Make use of experimental tools for innovation** to to assess high speed machining and rapid prototyping..	3
CO 4	PO 1	Identify (knowledge) to compare NC/CNC machines with interpolations accuracy and their functions and applications with the **fundamentals of mathematics, science, and engineering fundamentals**	3
	PO 2	Apply (knowledge) to conduct the experimental work the appropriate using **analytical synthetic mathematical tools**	2
	PO 3	Explain qualitatively about motion of CNC Machines in three-dimensions **using the principles of mathematics and engineering fundamentals.**	2
	PO 12	Apply the concept of adaption control techniques during the machining operation and optimise various machining parameters by **using CAD-CAM softwares .**	2
	PSO 1	**Focus on working digital manufacturing systems** to on CNC vertical machining centre.	3
CO 5	PO 1	Develop the computer assisted knowledge base and suboptimal process plans to improve **the process capability using probability mathematical models.**	3
	PO 2	Use the retrieval and generative type process plans to minimize the ideal time to **minimize the shortest possible path.**	2
	PO 5	make use of of different quality control methods which includes contact and non contact methods for establishing **digital manufacturing environment.**	2
	PSO 1	Interpret **process models to justify digital manufacturing criteria** for unmanned control.	3
CO 6	PO 1	**Construct the mathematical model of manufacturing model** through computer machined tool cell system using design and manufacturing tools	3
	PO 2	**Make use of experimental tools for innovation** to assess high speed machining and rapid prototyping.	2
	PO 3	Overview of different programming techniques applied in the **CNC machines to generate part program for simple and complex geometrics.**	2
	PSO 1	**Make use of experimental tools for innovation** to assess high speed machining and rapid prototyping.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	Program Outcomes/ No. of Key Competencies Matched												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	2	3	-	-
CO 3	3	-	2	-	2	-	-	-	-	-	-	2	3	-	-
CO 4	3	2	2	-	-	-	-	-	-	-	-	2	3	-	-
CO 5	3	2	-	-	2	-	-	-	-	-	-	-	3	-	-
CO 6	3	2	2	-	-	-	-	-	-	-	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	100	-	-	-	-	-	-	-	-	-	-	66.7	100	-	-
CO 3	100	-	66.7	-	66.7	-	-	-	-	-	-	66.7	100	-	-
CO 4	100	66.7	66.7	-	-	-	-	-	-	-	-	66.7	100	-	-
CO 5	100	66.7	-	-	66.7	-	-	-	-	-	-	-	100	-	-
CO 6	100	66.7	66.7	-	-	-	-	-	-	-	-		66.7	-	-

XV COURSE ARTICULATION MATRIX (CO –PO/ PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

2 - $40\ \% < C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	2	3	-	-
CO 3	3	-	2	-	2	-	-	-	-	-	-	2	3	-	-
CO 4	3	2	2	-	-	-	-	-	-	-	-	2	3	-	-
CO 5	3	2	-	-	2	-	-	-	-	-	-	-	3	-	-
CO 6	3	2	2	-	-	-	-	-	-	-	-		2	-	-
TOTAL	18	6	6	-	4	-	-	-	-	-	-	6	14	-	-
AVERAGE	3	2	2	-	2	-	-	-	-	-	-	2	2.8		-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

X	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**Introduction to CAD and Computer Graphics**
	Computers in Industrial Manufacturing, Product cycle, CAD / CAM Hardware, Basic structure, CPU, Memory types, input devices, display devices, hard copy devices, storage devices, Computer Graphics: raster scan graphics coordinate system, database structure for graphics modeling, transformation of geometry, 3D transformations, mathematics of projections, clipping, hidden surface removal.
MODULE II	**Geometrical Modelling and Drafting Systems**
	Requirements, geometric models, geometric construction models, curve representation methods, surface representation methods, solid modeling, modeling facilities desired, Basic geometric commands, layers, display control commands, editing, dimensioning.
MODULE III	**Introduction to Computer Aided Manufacturing**
	Introduction: Need of NC technology, Fundamental concepts in numeric control: structure and functions of NC System, advantages of NC technology over conventional manufacturing. NC Machine Tools: Types, Definition anddesignation of control axes,Special constructional and design characteristics of NC machine tools, Standard tooling used for NC turning and milling centres. Computer Numerical Control of Machine Tools: Types and functions of computer numeric control (CNC), Types and functions of direct numeric control (DNC), Need of adaptive control types, functions and types of adaptive control, its uses and benefits, Advantages of combined CNC/DNC systems
MODULE IV	**NC Part Programming**
	Work holding and tool setting procedure for NC turning and milling centres, Tool zero presetting, Block formats and introduction to ISO based G and M codes for NC part programming, Concepts of tool length and radius compensation, Standard canned cycles used in CNC turning and milling centres, Introduction to automatic NC part program generation from CAD models using standard CAD/CAM software for machining of surfaces, moulds and dies etc.

MODULE V	Computer Aided Engineering
	Group technology: Part family, coding and classification, production flow analysis, advantages and limitations, computer Aided Processes Planning, Retrieval type and generative type, terminology in quality control, the computer in QC, contact inspection methods, non-contact inspection methods, optical, computer aided testing, integration of CAQC with CAD/CAM.Types of manufacturing systems, machine tools and related equipment, material handling systems, computer control systems, human labor in the manufacturing systems, CIMS benefits.

TEXTBOOKS

1. IbrahimZeid, " Mastering CAD/CAM", McGraw-Hill, 1st Edition, 2007.
2. William M Neumann and Robert F.Sproull, "Principles of Computer Graphics", McGraw-Hill Book Co. Singapore,1st Edition, 1989.
3. Groover M. P, Zimmers. E. W., "CAD/CAM: Computer Aided Design Manufacturing", Pearson Education India, 1st Edition, 2006.

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1. YoramKoren, "Computer Control of Manufacturing Systems ", McGraw-Hill, 1st Edition,1983.
2. K. Lalit Narayan, K. Mallikarjuna Rao and M.M.M. Sarcar, "Computer Aided Design Manufacturing", PHI, 1st Edition, 2008.

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1. http:// nptel.ac.in/courses/112102101/
2. http:// nptel.ac.in/courses/112102103
3. https:/elsevier.com/books/curves-and-surfaces-for-cagd/farin/978-1-55860-737-8

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Discussion on OBE to equip the learning skills of students		
CONTENT DELIVERY (THEORY)			
1	Fundamentals of CAD/CAM, Design process, Application of computers for design	CO 1	T2:1, T1:1
2	Introduction to CAD and Computer Graphics approach	CO 1	T2:23
3	Computers in Industrial Manufacturing	CO 1	T2:3
4	Product cycle CAD / CAM Hardware	CO 1	T2:3
5	Basic structure CPU Memory types	CO 1	T2:2.7, R1:2.18
6	Input devices display devices hard copy devices	CO 1	T2:2.22
7	Storage devices , Graphics packages in present industry	CO 1	T2:2.25
8	Computer Graphics: raster scan graphics coordinate system	CO 1	T2:2.25

9	Database structure for graphics modeling	CO 2	T2:2.25
10	Transformation of geometry 3D transformations	CO 1	T2:2.26 R1:2.55
11	Mathematics of projections	CO 2	T2:2.16 R1:2.61
12	Clipping hidden surface removal.	CO 2	T2:2.16 R1:2.61
13	Geometrical Modelling and Drafting Systems	CO 2	T2:2.16 R1:2.61
14	Requirements geometric models	CO 2	T2:2.30 R1:2.58
15	Geometric construction models	CO 2	T2:2.30 R1:2.58
16	Curve representation methods	CO 2	T2:2.30 R1:2.58
17	Surface representation methods	CO 3	T2:2.30 R1:2.58
18	Solid modeling modeling facilities desired	CO 3	T2:3.14 R1:4.31
19	Basic geometric commands layers	CO 3	T2:3.14 R1:4.31
20	Display control commands editing dimensioning.	CO 3	T2:3.14 R1:4.33
21	Introduction to Computer Aided Manufacturing	CO 3	R1:4.36
22	Need of NC technology	CO 3	R1:4.36
23	Fundamental concepts in numeric control: structure and functions of NC System	CO 4	T2:3.18 R1:4.64
24	Advantages of NC technology over conventional manufacturing.	CO 4	T2:3.18 R1:4.64
25	NC Machine Tools: Types Definition	CO 4	T2:3.22 R1:4.67
26	Designation of control axes	CO 4	T2:3.22 R1:4.67
27	Special constructional and design characteristics of NC machine tools	CO 4	T2:3.22 R1:4.67
28	Standard tooling used for NC turning and milling centres	CO 4	T2:3.28 R1:4.67
29	Computer Numerical Control of Machine Tools: Types and functions of computer numeric control (CNC) Types and functions of direct numeric control (DNC)	CO 5	T2:4.2 R1:4.67
30	Need of adaptive control types functions and types of adaptive control	CO 5	T2:4.3 R1:4.71
31	CNC uses and benefits Advantages of combined CNC/DNC systems	CO 5	T1:4.8 R2:4.68
32	NC Part Programming Work holding and tool setting procedure for NC turning and milling centers	CO 5	T2:4.15 R1:5.74
33	Tool zero presetting Block formats	CO 5	T1:4.12 R2:5.75

34	Introduction to ISO based G and M codes for NC part programming	CO 5	T1:4.8 R2:5.72
35	Concepts of tool length and radius compensation	CO 5	T1:5.8 R1:5.73
36	Standard canned cycles used in CNC turning and milling centers	CO 5	T1:5.14 R1:6.78
37	Introduction to automatic NC part program generation from CAD models	CO 6	T2:5.19 R1:6.81
38	Standard CAD/CAM software for machining of surfaces molds and dies etc.	CO 6	T1:6.4 R2:6.8
39	Group technology: Part family coding and classification	CO 6	T2:7.7 R1:7.74
40	Production flow analysis advantages and limitations	CO 6	T1:7.12 R2:8.75
41	Computer Aided Processes Planning Retrieval type and generative type	CO 6	T1:7.8 R1:8.72
42	Terminology in quality control the computer in QC	CO 6	T1:8.8 R3:8.73
43	Contact inspection methods non-contact inspection methods	CO 6	T1:9.14 R1:10.78
44	Optical computer aided testing integration of CAQC with CAD/CAM,Types of manufacturing systems machine tools and related equipment	CO 6	T2:9.19 R1:10.814
45	Material handling systems computer control systems,Human labor in the manufacturing systems CIMS benefits.	CO 6	T1:10.4 R2:11.68
PROBLEM SOLVING/ CASE STUDIES			
1	Design a simple 2D floor plan for a house with at least three rooms, a kitchen, and a bathroom. Use appropriate symbols and dimensions.	CO 1	T1: 1.1-1.5, T2 : 4.1
2	You have been given the task to design a simple 3D model of a house. Create a CAD model that includes the exterior walls, doors, windows, and a roof. Pay attention to the dimensions and proportions to ensure the house looks realistic. Add some basic interior elements like walls, furniture, and fixtures to complete the model.	CO 2	R2: 1.1-1.5, T1: 4.1
3	Design a custom bottle using surface modeling techniques in CAD. The bottle should have a unique shape with smooth curves and complex contours. Ensure that the model is suitable for 3D printing or manufacturing	CO 1	T1: 1.1-1.5, T2 : 4.1
4	Prepare a 3D model for 3D printing by optimizing the geometry, checking for potential issues like non-manifold geometry or intersecting parts, and adding necessary supports to ensure a successful and clean print.	CO 2	R2: 1.1-1.5, T1: 4.1
5	Given a 3D model of a building or an object, perform perspective projection to create a 2D representation of the model as seen from a specific viewpoint. Pay attention to the correct foreshortening and depth perception in the resulting projection.	CO 2	R2: 1.1-1.5, T1: 4.1

6	Design a 3D model of a complex mechanical part with intricate geometries using a parametric modelling approach.	CO 2	T2: 1.1-1.5, T1: 4.1
7	Develop a geometric algorithm to generate a 3D pattern of a well-known shape (e.g., a torus, gear) with customizable parameters like diameter, thickness, and number of teeth.	CO 3	T2: 1.1-1.5, T1: 4.1
8	Given an engineering drawing of a machine component, create a detailed 2D orthographic projection with proper dimensioning and annotations.	CO 3	T2: 1.1-1.5, T1: 4.1
9	Develop a drafting template for a company's standard title block, incorporating fields for part names, numbers, revisions, and other relevant information.	CO 3	R2: 1.1-1.5, T1: 4.1
10	Apply geometric dimensioning and tolerancing (GD and T) principles to a given part drawing, ensuring proper communication of design intent and allowable variations.	CO 4	T2: 1.1-1.5, T1: 4.1
11	Create a CNC program to machine a 3D model using different tooling operations (e.g., roughing, finishing, drilling).	CO 4	R2: 1.1-1.5, T1: 4.1
12	Develop a G-code program to machine a simple 2D profile on a CNC milling machine, considering tool selection, feed rates, and toolpath strategy.	CO 4	T2: 1.1-1.5, T1: 4.1
13	Create a CNC program to perform pocketing operations on a rectangular workpiece, considering toolpaths, feeds, speeds, and cutter compensation.	CO 5, CO 6	T2: 1.1-1.5, T1: 4.1
14	Given a 2D drawing of a mechanical component, develop the G-code to program a CNC milling machine to manufacture the part accurately.	CO 5, CO 6	R2: 1.1-1.5, T1: 4.1
15	Perform a structural analysis of a bridge using FEA to determine stress and displacement under various loading conditions.	CO 5, CO 6	R2: 1.1-1.5, T1: 4.1
	DISCUSSION OF DEFINITION AND TERMINOLOGY		
1	Computers in Industrial Manufacturing, Product cycle, CAD / CAM,database structure for graphics modeling, transformation of geometry,mathematics of projections	CO 1	R4:2.1
2	Geometric construction models, curve representation methods, surface representation methods, control commands, editing, dimensioning	CO 2	R4:2.1
3	Types and functions of computer numeric control,Fundamental concepts in numeric control, Standard tooling used for NC turning and milling centres.	CO 3, CO 4	R4:2.1
4	Concepts of tool length and radius compensation,ISO based G and M codes for NC part programming, procedure for NC turning and milling centres	CO 5	R4:2.1
5	Integration of CAQC with CAD/CAM.Types of manufacturing systems, CIMS benefits,Computer Aided Processes Planning	CO 6	R4:2.1
	DISCUSSION OF QUESTION BANK		
1	Fundamental concepts in CAD	CO 1	R4:2.1
2	Geometrical modelling and drafting systems	CO 2	T4:7.3

3	Computer Aided Manufacturing	CO 3,4	R4:5.1
4	NC part program generation from CAD models	CO 5	T1:7.5
5	Group Technology, CAPP and CAQC	CO 6	T1: 4.1

Signature of Course Coordinator **HOD, ME**

Mr. V. Mahidhar Reddy, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**CAD / CAM LABORATORY**				
Course Code	AMEC48				
Program	B.Tech				
Semester	VII	MECHANICAL			
Course Type	Core				
Regulation	IARE - UG 20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
		-	-	3	1.5
Course Coordinator	Mr. V. Mahidhar Reddy , Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AMEC25	V	Machine Tools and Metrology Laboratory	1.5

II COURSE OVERVIEW:

Computer aided Design/ Computer aided Manufacturing (CAD/CAM) laboratory is a course primary important to mechanical engineering students. The aim is to impart the overview of computer applications or design and manufacturing the discrete engine components, assemblies and final product to meet the global competition. The course covers the life cycle of a product describes the product model generation, analysis structural, thermal, dynamic behaviors. This course also deals with creation of synthetic curves and surfaces. It imposes the knowledge of latest manufacturing techniques using CNC/DNC Machines centers with different CNC programming methods, Manufacturing processes, Group Technologies.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
CAD / CAM Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

X	Demo Video	✓	Lab Worksheets	✓	Viva Questions	X	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
-	-	-	-	-	-

VI COURSE OBJECTIVES:

The students will try to learn:

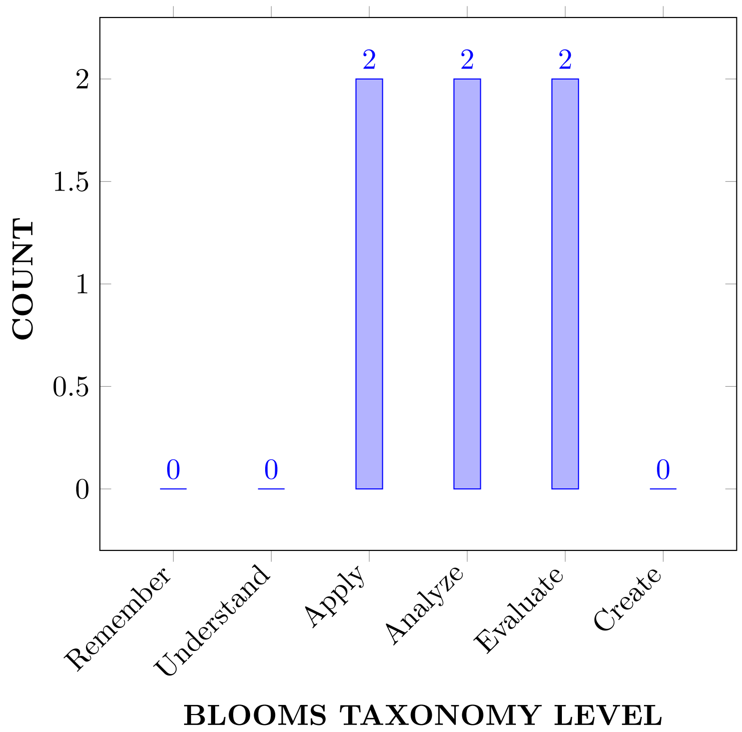
I	The 2D drawings of machine components and modify commands for simple geometric assemblies
II	The 2D Sectinal views for part drawing and assemblies, and generation of 2D, 3D models through different features
III	The Simulation software used for anlyse stresses in various beams and truss
IV	The fundamentals of CNC turning and milling, Part programming and interpolation techniques using CAM software.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Eplain** the concept of numerical control system and advantages of CNC machine tools.	Evaluate
CO 2	**Examine** the working of CNC milling and familiarization of machine control panel.	Analyze
CO 3	**Determine** the stress and deflection in bar,beam and trusses using simulation software	Evaluate
CO 4	**Generate** part programming through CAM software on CNC simulator for machining.	Apply
CO 5	**Make use of** various Work piece setting methods and tool setting methods for CNC bed	Apply
CO 6	**Inspect** CNC programming for execution on milling and turning machines.	Analyze

COURSE COURSE KNOWLEDGE COMPETENCY LEVEL:



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Program Outcomes	
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE / SEE/ Lab Exercises
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3	CIE / SEE/ Lab Exercises

PO 5	**Modern tool usage:** UCreate, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	3	CIE / SEE/ Lab Exercises

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	2	-	-	-	-	-	-	-	-	-	-	-	2
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 4	2	-	-	-	2	-	-	-	-	-	-	-	-	-	2
CO 5	2	-	2	-	-	-	-	-	-	-	-	-	-	-	2
CO 6	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV 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	Explain qualitatively about motion of CNC Machines in three-dimensions using **the principles of mathematics and engineering fundamentals.**	2
	PO 3	Application of synthetic and free form surface generation equations to**create coon's surfaces on CNC machine centres and 2D contour surfaces on turning centres through simulation techniques.**	2
	PSO 3	Apply **(Knowledge)** The application of high speed techniques by **using latest art of cutting tools technology for hard to machine components**	2
CO 2	PO 2	Use the retrieval and generative type process plans to minimize the ideal time to **minimize the shortest possible path**	2
CO 3	PO 1	Use the mathematical model **to justify ABC Analysis and economic order quantities in manufacturing planning**	2
	PSO 3	Apply **(Knowledge)** the experimental tools for innovation **to assess high speed machining and rapid prototyping**	2
CO 4	PO 1	Recognize (knowledge) the importance and application (apply) of dimensions, units and dimensional homogeneity in solving (complex) engineering problems with specific emphasis to fluid mechanics by applying the	2
	PO 5	Understand the **problem statement and formulate** the dimensional analysis and similarity parameters for predicting physical parameters that govern fluid systems in designing prototypes devices	2
	PSO 3	Apply (knowledge) concept of dimensional analysis and similarity parameters for predicting physical parameters (understanding) for the fluid flow analysis used in designing prototypes devices (apply) solving design problems by applying the **principles of Mathematics, Science and Engineering**	2
CO 5	PO 1	Apply the basic conservation laws of science for various phenomena of fluid systems and use **mathematical principles** for deriving (complex) fluid flow engineering equations by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals**of fluid mechanics.	2
	PO 3	Understand the given **problem statement** and formulate (complex) fluid flow engineering phenomena and system for deriving various governing equations of fluid mechanics from the provided information and substantiate with the **interpretation** of variations in the results.	2

	PO 5	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of fluid mechanics.	2
	PSO 3	Apply (knowledge) concept of dimensional analysis and similarity parameters for predicting physical parameters (understanding) for the fluid flow analysis used in designing prototypes devices (apply) solving design problems by applying the **principles of Mathematics, Science and Engineering**	2
CO 6	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** principles to understand the Bernoulli Equation for real flows and its applications	2
	PO 3	Using Euler equation of motion derive the Bernoulli equation to analyze complex fluid flow problems using **principles of mathematics and engineering sciences**	2

XV SYLLABUS:

WEEK 1	**INTRODUCTION TO CAD SOFTWARE**
	Problem Statement: Familiarization and practicing of drawing and modifying commands, template creation, lettering, object snapping and sectioning **Solutions Expected:** 1. Template Creation: Start by creating a custom template for your CAD drawings. Set up the template with the necessary drawing units, title block, company logo, and any other standard information you want to include on all your drawings. 2. Drawing Basics: Familiarize yourself with basic drawing commands, such as line, polyline, circle, arc, rectangle, etc. Practice creating simple shapes using these commands. 3. Modifying Commands: Learn common modifying commands like erase, trim, extend, fillet, chamfer, mirror, etc. These commands are essential for editing and refining your drawings.

WEEK 2	**DRAFTING OF SIMPLE 2D DRAWINGS**
	Problem Statement: Prepare the 2D drawings using draw and modify commands for simple geometric assemblies, sectional views for part drawing and assemblies. **Solutions Expected:** 1. Create a New Drawing: Open your CAD software and create a new 2D drawing. Use the template you created earlier, or use a default template if available. 2. Draw Individual Parts: Start drawing each individual part of the assembly using appropriate draw commands like line, polyline, circle, arc, etc. Use object snapping to accurately place and align the components. 3. Assemble the Parts: Arrange the individual parts to create the assembly. Use drawing aids like grids and alignment tools to ensure proper positioning. 4. Iterate and Improve: Don't hesitate to iterate and make improvements to your drawing. Seek feedback from peers or mentors to enhance your skills further.
WEEK 3	**SOLID MODELING**
	Problem Statement: Preparing the 2D and 3D models (wire frame, surface and solid models) by using B-REP, CSG. Introduction of Boolean operations. Generation of 2D, 3D models through protrusion, revolve, sweep. **Solutions Expected:** 1. Understanding B-REP and CSG: Familiarize yourself with the concepts of B-REP and CSG. B-REP represents objects as surfaces and edges, while CSG represents objects as combinations of simple geometric primitives (e.g., cubes, cylinders, spheres) using Boolean operations (e.g., union, intersection, subtraction). 2. 2D Modeling: Begin with 2D modeling by using drawing and sketching tools to create the base profiles of your 3D objects. Use techniques like lines, arcs, circles, and splines to draw your shapes. 3. CSG Modeling: Start with simple geometric primitives (e.g., cubes, cylinders, spheres) and use Boolean operations (e.g., union, intersection, subtraction) to combine and modify these shapes to create more complex objects.

WEEK 4	**CREATING ORTHOGRAPHIC VIEWS FROM SOLID MODELS**
	Problem Statement: Development of orthographic views for assembly drawings and preparation of bill of materials (IC engine components, Machine tool accessories, Jigs and Fixtures). **Solutions Expected:** 1. Gather Information: Collect all the necessary information, specifications, and drawings for the components you want to include in the assembly drawing and bill of materials. 2. Orthographic Views: Generate orthographic views (front, top, right, etc.) of the assembly by projecting the individual components onto the corresponding planes. 3. Solid Modeling: Use the modeling techniques you've learned to create complete solid models by combining and modifying multiple 2D and 3D shapes.
WEEK 5	**INTRODUCTION TO SIMULATION SOFTWARE**
	Problem Statement: Basic commands used in Simulation Software (Eg. Ansys, Hyperworks, etc.) and related simulation methodologies. **Solutions Expected:** 1. Preprocessing: Geometry Import: Import the CAD model of the system to be analyzed. Meshing: Generate finite element mesh using tetrahedral, hexahedral, or other element types. Material Assignment: Assign material properties to different parts of the model. Boundary Conditions: Apply constraints and loads to represent the operating conditions. Contact Definitions: Define contact between different parts of the model if required. 2. Solvers: Static Analysis: Perform a static simulation to study the deformation and stresses under a given load. Modal Analysis: Calculate natural frequencies and mode shapes of the structure. Transient Analysis: Analyze time-dependent behavior, such as impact or dynamic loading. Buckling Analysis: Study the buckling behavior and critical load of the structure. 3. Postprocessing: Visualization: Visualize the results using contour plots, deformed shapes, animations, etc. Result Probing: Extract specific values like stresses, displacements, or reaction forces at certain points.

<table>
<tr><td>WEEK 6</td><td>SIMPLE BEAM</td></tr>
<tr><td></td><td>Problem Statement: Determination of deflection and stresses in bar
Solutions Expected:

Analytical Method: For simple cases like a bar subjected to axial loading (tensile or compressive), you can use basic engineering equations.
Finite Element Analysis (FEA): FEA is a numerical method widely used to determine deflection and stresses in complex structures, including bars with irregular shapes or loads.
Experimental Methods: In some cases, it might be necessary to perform physical tests on a prototype or a scaled model of the bar to measure the deflection and stresses directly.
</td></tr>
<tr><td>WEEK 7</td><td>TRUSSES</td></tr>
<tr><td></td><td>Problem Statement: Simulation and analysis of a truss
Solutions Expected:

Create the Truss Model: Start by creating a 3D model of the truss structure in your CAD software. Ensure the model accurately represents the physical truss with proper connectivity of nodes and members.
Import the Model into Simulation Software, Apply Material Properties,Mesh Generation,Boundary Conditions,Apply Loads and Run the Simulation
</td></tr>
<tr><td>WEEK 8</td><td>CANTILEVER BEAM-1</td></tr>
<tr><td></td><td>Problem Statement: Simulation and analysis of a cantilever beam with load
Solutions Expected:

To simulate and analyze a cantilever beam with load, you can use Finite Element Analysis (FEA) in simulation software like ANSYS, Abaqus, or SolidWorks Simulation. Here's a step-by-step guide:
Create the Cantilever Beam Model,Import the Model into Simulation Software,Apply Material Properties,Mesh Generation,Boundary Conditions,Apply Load and Run the Simulation
</td></tr>
</table>

WEEK 9	**CANTILEVER BEAM-2**
	Problem Statement: Simulation and analysis of a cantilever beam with UDL. **Solutions Expected:** 1. To simulate and analyze a cantilever beam with a Uniformly Distributed Load (UDL), you can use Finite Element Analysis (FEA) in simulation software like ANSYS, Abaqus, or SolidWorks Simulation. Here's a step-by-step guide: 2. Create the Cantilever Beam Model,Import the Model into Simulation Software,Apply Material Properties,Mesh Generation,Boundary Conditions,Apply Uniformly Distributed Load and Run the Simulation
WEEK 10	**INTRODUCTION TO CAM**
	Problem Statement: Basic fundamentals of CNC milling, familiarization of machine control panel, Part programming and interpolation techniques using CAM software. **Solutions Expected:** 1. Basic Fundamentals of CNC Milling 2. Familiarization of Machine Control Panel 3. Part Programming using CAM Software 4. Interpolation Techniques using CAM Software
WEEK 11	**CNC MILLING**
	textbf Problem Statement: Machining practice on CNC milling **Solutions Expected:** 1. Machining practice on CNC milling involves a series of steps to operate the CNC milling machine effectively and produce accurate machined parts. Here are the key solutions and steps you can follow: 2. Machine Setup, CNC Machine Homing and Initialization, Load and Verify Part Program,Workpiece Measurement and Alignment, Tool Length Measurement, Dry Run and Tool Path Verification, Cutting Parameters,Machining Operation, Inspection and Quality Control, Post-Processing

WEEK 12	**CNC TURNING**
	textbf Problem Statement: Machining practice on CNC Turning. **Solutions Expected:** 1. Machining practice on CNC turning involves several key steps to operate the CNC lathe efficiently and produce accurate machined parts. Here are the solutions and steps you can follow: 2. Machine Setup, CNC Machine Homing and Initialization, Load and Verify Part Program,Workpiece Measurement and Alignment, Tool Length Measurement, Dry Run and Tool Path Verification, Cutting Parameters,Machining Operation, Inspection and Quality Control, Post-Processing.

TEXTBOOKS

1. IbrahimZeid, "MasteringCAD/CAM", McGraw-Hill,1st Edition,2007
2. William M Neumann and Robert F.Sproull, "Principles of Computer Graphics", McGraw-Hill Book Co.Singapore, 1st Edition, 1989.
3. Groover M. P, Zimmers. E. W., "CAD/CAM: Computer Aided Design Manufacturing", Pearson Education India, 1st Edition, 2006

REFERENCE BOOKS:

1. YoramKoren, "ComputerControlof ManufacturingSystems", McGraw-Hill,1 st Edition,1983.
2. K. Lalit Narayan, K. Mallikarjuna Rao and M.M.M. Sarcar, "Computer Aided Design Manufacturing", PHI, 1st Edition, 2008.
3. D. S. Kumar, Heat and Mass Transfer, S.K. Kataria & sons, 9th Edition 2015.

XVI COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Understand Numerical control, its function and advantages	CO 1	T1.2.2
2	Understand Evolution of CNC and classification of CNC machine tools	CO 2	T1.2.5, R2: 3.5, R3: 2
3	Understand Basic fundamentals of CNC milling, familiarization of machine control panel.	CO 3	T2.2.2,R1: 3.4
4	Fundamentals of CNC programming, Part programming and interpolation techniques.	CO 4	T2.2.9,R1: 2.2
5	Machining practice on CNC milling.	CO 5	T2.2.8, R1: 2.4
6	Generation of part programming through CAM software package.	CO 6	T2.3.2,R2: 4.5
7	CAM-CNC programming and execution	CO 4	T1.2.2, R2: 4.6

8	Work piece setting methods, tool setting methods.	CO 5	T3.2.2,R2: 5.1
9	Practice on CNC turning and exercises on machine.	CO 6	R2: 5.2
10	Generation of part programming through the CAM software package, CAM-CNC programming and execution on milling and turning machines.	CO6	R1: 7.1
11	Determination of deflection and stresses in 2D and 3D Beams plot the graphs for the responses developed inside the model using ansys workbench software	CO 6	R1:7.2
12	How The Heat Effect On The Machine Bed, Tool Holder Can Be Taken Care	CO 6	R1:7.3

XVII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design and develop the piston rings model in CNC lathe machine.
2	Design and develop the combustion chamber model in CNC Milling and turning machine .
3	Prototyping: Design and develop of Connecting Rod using CNC machining.

Signature of Course Coordinator **HOD,ME**
Mr. V. Mahidhar Reddy, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**					
Course Title	**PRODUCTION PLANNING CONTROL**					
Course Code	AMEC56					
Program	B.Tech					
Semester	VIII					
Course Type	ELECTIVE					
Regulation	UG-20					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	3	-	3	-	-	
Course Coordinator	Mr R.Srinivas, Assistant Professor					

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB05	III	Manufacturing Process
B.Tech	AMEB16	V	Manufacturing Technology

II COURSE OVERVIEW:

Production planning and control refers two strategies that work cohesively throughout the manufacturing process. It involves what to produce, when to produce it, how much to produce, and more. Production system requires the optimal utilization of natural resources like man power, money, machine, materials and time. A long-term view of production planning is necessary to fully optimize the production flow based the utilization of resource allocation of activities of employees, materials and production capacity. to develop, manage and control all aspects of an effective and efficient manufacturing planning and control system- a key to the success of any product manufacturing company

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Production Planning Control	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), and 10 marks for Alternative Assessment Tool (AAT).

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
16.6%	Remember
50%	Understand
0%	Apply
33.3 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

<table>
<tr><th colspan="2">Component</th><th>Marks</th><th>Total Marks</th></tr>
<tr><td rowspan="4">CIA</td><td>Continuous Internal Examination – 1 (Mid-term)</td><td>10</td><td rowspan="4">30</td></tr>
<tr><td>Continuous Internal Examination – 2 (Mid-term)</td><td>10</td></tr>
<tr><td>AAT-1</td><td>5</td></tr>
<tr><td>AAT-2</td><td>5</td></tr>
<tr><td>SEE</td><td>Semester End Examination (SEE)</td><td>70</td><td>70</td></tr>
<tr><td colspan="3">Total Marks</td><td>100</td></tr>
</table>

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

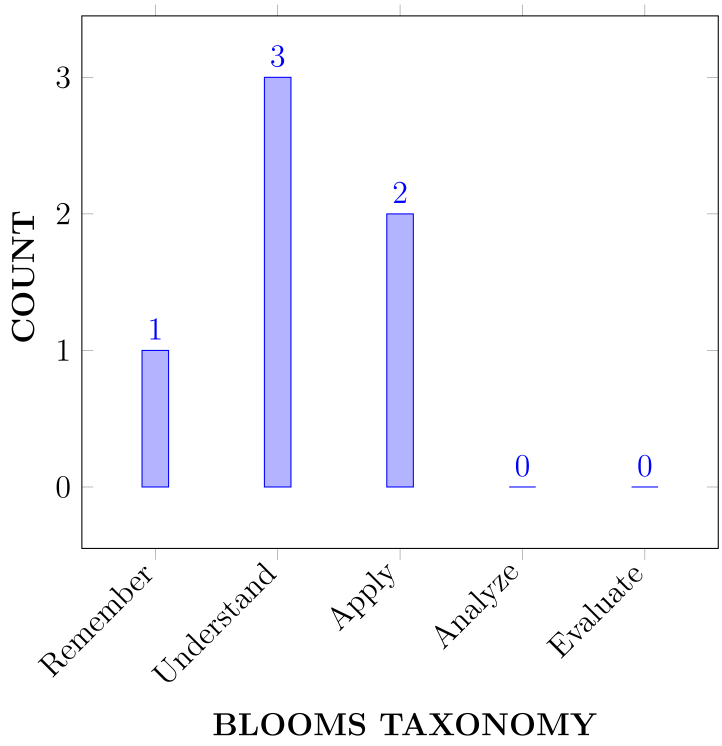
I	To develop, manage and control all aspects of an effective and efficient manufacturing planning and control system which is a key component to the success of any product manufacturing company.
II	The Methodology and models related to forecasting, business operations and productivity in supply chain management
III	The Strategies of capacity planning, materials requirements, inventory models,scheduling methods in various aspects of the manufacturing and service industry

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Define** different inventory methods in Production Planning that empower manufacturers to enhance smarter and optimized production process. Show the necessity and importance of expediting based on functionality, cost and time in development of business activity.	Remember
CO 2	**Classify** various Forecasting techniques (Qualitative & Quantities) to provide valuable inputs for number of planning decisions and continuous improvement.	Understand
CO 3	**Explain** different types of inventories and select the ordering quantity for minimizing the operation cost. Master Production Schedule and a resultant Materials Requirement Plan (MRP)for a complete production facility.	Understand
CO 4	**Identify** the forecasting models and errors associated with production to develop business enterprise for product demand, profits, sales, material requirements and the capacity planning process for business operations.	Apply
CO 5	**Make use of** the impact of production/inventory cost decisions and operations strategies on the break-even, return on investment and profit analysis of a business enterprise Apply forward and backward scheduling policies to analyze different job shop schedules with reference to prioty rules.	Apply
CO 6	**Summarize** production and inventory planning/control systems and scheduling techniques by using engineering techniques for a complete production facility. Make use of centralized and decentralized dispatching techniques forproduct delivery as per customer needs.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
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PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (Conduct Investigations of Complex Problems).
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations (Modern Tool Usage).
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/CIA
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	SEE/CIA
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	SEE/CIA
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	SEE/CIA
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	1	SEE/CIA
PSO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	1	SEE/CIA

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	2	Discussion /AAT
PSO 3	Make use of computational and experimental tools for building career paths towards innovative startups, employability and higher studies.	1	SEE/CIA

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	✓	-	-	-	-	-	-	-	✓	-	-	-	-
CO 2	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	✓	✓	-	-	-	-	-	-	-	-	✓	✓	-	✓
CO 5	-	✓	✓	-	-	-	-	-	-	-	✓	-	✓	-	-
CO 6	-	✓	-	-	-	✓	-	-	-	-	-	-	-	-	

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Define different inventory methods in Production Planning that empower manufacturers to enhance smarter and optimized production process by applying the **scientific principles** of **mathematics and science**	2
	PO 2	Understand the given **problem statement** and apply **data validation** techniques to solve (complex) **specific engineering problems** related to design	3
	PO 3	Forging techniques for the development of critical products for public **health and safety**, and the **cultural, societal** and **Environmental considerations**	3
	PO 11	Demonstrate knowledge and understanding ofEngineering and management principles and Apply these to ones own work, as a member and leader in a team, to Relate projects and in **multidisciplinary environments**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO 1	Recall (knowledge) different inventory methods in Production Planning that empower manufacturers to enhance smarter and optimized production process by applying the **scientific principles** of **mathematics and science**.	2
CO 3	PO 2	Understand the given **problem statement** and apply **data validation** techniques to solve (complex) **specific engineering problems** related to design	3
	PO 3	Forging techniques for the development of critical products for public **health and safety**, and the **cultural, societal** and **Environmental considerations**	3
CO 4	PO 2	Understand the given **problem statement** and apply **data validation** techniques to solve (complex) **specific engineering problems** related to design.	3
	PO 3	Forging techniques for the development of critical products for public **health and safety**, and the **cultural, societal** and **Environmental considerations**	3
	PO 12	Identify the need for and have the preparation and ability To take part in independent and **life- long learning** in the broadest context of **technological change**	2
	PSO 1	To Construct engineering professional capable of synthesizing and **analyzing mechanical systems** including allied engineering streams.	1
	PSO 3	Make use of **computational and experimental tools** forcreating innovative career paths, to be an entrepreneur and desire for **higher studies in the field of production planning and control**	2
CO 5	PO 2	Understand the given **problem statement** and apply **data validation** techniques to solve (complex) **specific engineering problems** related to design.	3
	PO 3	Forging techniques for the development of critical products for public **health and safety**, and the **cultural, societal** and **Environmental considerations**	3
	PO 11	Demonstrate knowledge and understanding of **Engineering and management principles** and Apply these to ones own work, as a member and leader in a team, to Relate projects and in **multidisciplinary environments.**	2
	PSO 1	To Construct engineering professional capable of synthesizing and **analyzing mechanical systems** including allied engineering streams	1
CO 6	PO 2	Understand the given **problem statement** and apply **data validation** techniques to solve (complex) **specific engineering problems** related to design.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 6	Apply reasoning informed by contextual knowledge to assess **societal, health, safety, legal and cultural issues** and the consequent responsibilities Classify the professional engineering practice.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	3	3	-	-	-	-	-	-	-	2	-	-	-	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	3	3	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	3	3	-		-	-	-	-	-	-	2	1	-	2
CO 5	-	3	3	-	-	-	-	-	-	-	2	-	1	-	-
CO 6	-	2	-	-	-	2	-	-	-	-	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66	30	30	-	-	-	-	-	-	-	16	-	-	-	-
CO 2	66	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	30	30	-		-	-	-	-	-	-	-	-	-	-
CO 4	-	30	30	-	-	-	-	-	-	-	-	16	50	-	100
CO 5	-	30	30	-		-	-	-	-	-	16	-	50	-	-
CO 6	-	20	-	-	-	20	-	-	-	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 - $5 < C \leq 40\%$ – Low/ Slight
2 - $40\% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	1	-	-	-	-	-	-	-	1	-	-	-	
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	1	1	-	-	-	-	-	-	-	-	1	2	-	3

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 5	-	1	1	-	-	-	-	-	-	-	1	-	2	-	-
CO 6	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-
TOTAL	6	5	4	-	-	1	-	-	-	-	2	1	4	-	3
AVERAGE	3	1	1	-	-	1	-	-	-	-	1	1	2	-	1

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**OVERVIEW OF PRODUCTION PLANNING CONTROL**
	Introduction: Definition, Objectives of production planning and control, functions of production planning and control, elements of production control, types of production, organization of production planning and control department, internal organization of department
MODULE II	**FORECASTING**
	Forecasting: Importance of forecasting, types of forecasting, their uses, general principles of forecasting, forecasting techniques, qualitative methods and quantitive methods; Inventorymanagement, functions of inventories relevant inventory costs ABC analysis, VED analysis, EOQ model, inventory control systems, P-Systems and Q-Systems.
MODULE III	**INTRODUCTION TO MRP**
	Introduction to MRP and ERP, LOB (Line of Balance), JIT inventory, and Japanese concepts. Routing, definition, routing procedure Route sheets, bill of material, factors affecting routing procedure, Schedule, definition, difference with loading.
MODULE IV	**SCHEDULING**
	Scheduling Policies, techniques, Standard scheduling methods; Line balancing, aggregate planning, chase planning, expediting, controlling aspects
MODULE V	**DESPATCHING**
	Dispatching: Activities of dispatcher, dispatching procedure, followup, definition, reason for existence of functions, types of followup, applications of computer in production planning and control.

TEXTBOOKS

1. Frank M. White, "PPC ", McGraw Hill Education Private Limited, 8th Edition, 2017 .

REFERENCE BOOKS:

1. Yuan S W, "Line production", Prentice-Hall, 2nd Edition, 1987.

WEB REFERENCES:

1. https://nptel.ac.in/courses/1526489/1

COURSE WEB PAGE:

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

OBE DISCUSSION			
S.No	Course Description on Outcome Based Education (OBE): Course Objectives, Course Ourcomes(CO), Program Outcomes(PO) and Co - PO Mapping	-	-
CONTENT DELIVERY (THEORY)			
S.No	**Topics to be covered**	**CO's**	**Reference T1: 4.1**
1	Introduction: Definition, Objectives of production planning and control	CO 1	T2:2.3
2	Functions of production planning and control, elements of production control	CO 1	T1:2.6
3	Types of production, organization of production planning and control	CO 1	T1:2.6
4	Department, internal organization of department.	CO 1	T2:2.7 R1:2.18
5	Forecasting: Importance of forecasting	CO 2	T2:2.22
6	Types of forecasting, their uses	CO 2	T2:2.25
7	General principles of forecasting	CO 2	T2:2.26 R1:2.55
8	All the factors affecting the Forecasting	CO 2	T2:1.51
9	Information required for production plannning	CO 2	T2:2.26
10	Qualitative methods and quantitive methods	CO 2	T2:3.56
11	Inventory management, functions of inventories relevant	CO 2	T2:2.81
12	inventory costs ABC analysis, VED analysis, EOQ model, inventory control systems,	CO 2	T2:3.96
13	PSystems and Q-Systems	CO 2	T2:2.16 R1:2.61
14	Introduction to MRP and ERP	CO 3	T2:2.30 R 1:2.58
15	LOB (Line of Balance), JIT inventory, and Japanese concepts.	CO 3	T2:3.6 R1:4.29
16	Routing, definition, routing procedure Route sheets	CO 3	T2:3.14 R1:4.31
17	Bill of material, factors affecting routing procedure	CO 3	T2:3.14 R1:4.33
18	Schedule, definition, difference with loading.	CO 3, CO 4	R1:4.36

19	Scheduling Policies	CO5	T2:3.18 R1:4.64
20	Techniques, Standard scheduling methods	CO 5	T2:3.12
21	Advantages and Limitation of scheduling methods	CO 5	T2:3.13
22	Line balancing	CO 5	T2:4.14
23	Aggregate planning	CO 5	T2:4.15
24	Chase planning, expediting, controlling aspects	CO 5	T2:5.16
25	Forecasting techniques, qualitative methods and quantitive Methods	CO 5	T2:3.22
26	Forecasting techniques, qualitative methods and quantitive methods	CO5	T2:3.28 R1:4.67
27	Inventory management, functions of inventories	CO 5	T2:4.2
28	Inventory management, functions of inventories	CO 3	T2:4.3 R1:4.71
29	Relevant inventory costs ABC analysis, VED analysis	CO 5	T1:4.8 R2:4.68
30	Relevant inventory costs ABC analysis, VED analysis	CO 5	T2:4.15 R1:5.74
31	Methods in line balancing and production out put control	CO 5	T2:7.18
32	concept of Just In Time manufacturing	CO 5	T2:6.19
33	Explaining Kaban and Pull sytem	CO 5	T2:9.20
34	Implimentation of ERP software in supply chain management	CO 6	T2:5.21
35	Dispatching: Activities of dispatcher	CO 6	T2:7.12
36	Dispatching procedure	CO 6	T1:4.12 R2:5.75
37	Follow up, definition, reason for existence of functions,	CO 6	T1:4.8 R1:5.72
38	Types of follow up	CO 6	T1:5.8 R1:5.73
39	Applications of computer in production planning and control.	CO 6	T1:5.14 R1:6.78
40	Activities,follow up incomputer in production planning and control	CO 6	T2:5.19 R1:6.81
PROBLEM SOLVING/ CASE STUDIES			
1	Calculating EOQ using ABC Analysis	CO 3	R2:7.5
2	Calculate Demand as per the previous years sales	CO 3	R2:4.5
3	Calculating XYZ using ABC Analysis	CO 3	R2:2.5
4	Calculate out put of production using program evalaute review technique	CO 3	R2:5.5
5	supply chain management calculations based on the routes	CO 6	R2:6.5
6	ERP, LOB (Line of Balance)	CO 3, CO 2	T1:6.4 R2:6.8
7	ERP, LOB (Line of Balance)	CO 2, CO4	T2:7.7 R1:7.74

8	JIT inventory, and Japanese concepts	CO 1, CO 5	T1:7.12 R2:8.75
9	JIT inventory, and Japanese concepts	CO 3, CO 2	T1:7.8 R1:8.72
10	Definition : Routing System	CO 3, CO 2	T1:8.8 R1:8.73
11	Routing procedure Route sheet	CO 6, CO 1	T1:9.14 R1:10.78
12	Listing the costs associated with inventories	CO 3, CO 4	T2:8.24
13	Inventory control models with shortges	CO 2, CO 5	T2:9.86
14	Estimation of dynamic demand inventory problems	CO 3, CO 4	T2:8.45
15	All EOQ problems with price break	CO 5, CO6	T2:6.75
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Overview of Production Planning Control	CO 1	R2:2.5
2	Forecasting in Production Planning Control	CO 2	R2:6.5
3	Introduction to MRP and Routing	CO 3, CO 4	R2:1.5
4	Scheduling in Production Planning Control	CO 5	R2:4.5
5	Dispatching in Production Planning Control	CO 6	R2:6.5
DISCUSSION OF QUESTION BANK			
1	Overview of Production Planning Control	CO 1	R4:1.1
2	Forecasting in Production Planning Control	CO 2	T4:5.3
3	Introduction to MRP and Routing	CO 3, CO 4	R4:6.1
4	Scheduling in Production Planning Contro	CO 5	T1:3.5
5	ispatching in Production Planning Control	CO 6	T1: 2.1

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**POWER PLANT ENGINEERING**				
Course Code	AMEC53				
Program	B.Tech				
Semester	VIII				
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	-	-
Course Coordinator	Dr. Paidi Raghavulu, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AMEC13	IV	Applied Thermodynamics	3

II COURSE OVERVIEW:

Providing an overview of Power Plants and detailing the role of Mechanical Engineers in their operation and maintenance and to address the underlying concepts, methods and application of different thermal Power Plants

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Power Plant Engineering	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
✓	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Concept Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination..

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question. The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
20%	Understand
70%	Apply
0%	Analyze
0%	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
	Continuous Internal Examination – 2 (Mid-term)	10	
	AAT-1	5	
	AAT-2	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			100

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

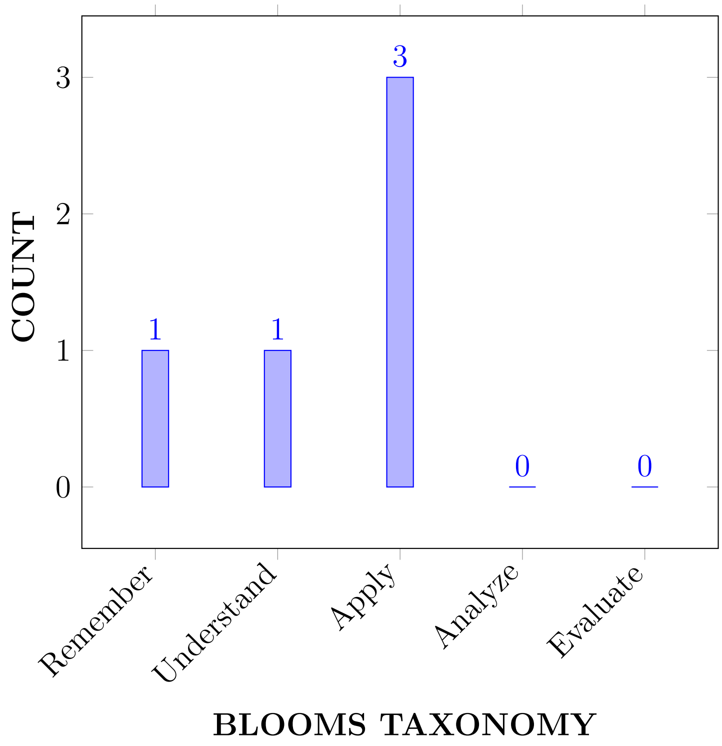
I	The various sources of energy, working of thermal power plants and combustion process..
II	The familiarize of working various power plants based on different fuels
III	The principles of economics and environmental issues.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the economics involved in power plants and identify the factors related to selection of plant	Remember
CO 2	**Discuss** the various components of steam power plants and factors influencing the site selection for the plant.	Apply
CO 3	**Illustrate** the working principle and basic components of the nuclear power plant and the economic safety principles involved with it.	Apply
CO 4	**Analyze** different types of sources and mathematical expression related thermodynamics and various factors involved with power plant opeartions.	Apply
CO 5	**Identify** power generation from renewable/ alternate fuels and heat sources such as bio fules, geothermal and solar thermal power plant for alternative power generations sources	Understand
CO 6	**Explain** the control methods of major pollutant emitted from fossil fuels which impact on air quality, climate change water and land	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	SEE/CIA
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	SEE/CIA
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	SEE/CIA
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	SEE/CIA
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	SEE/CIA

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of and need for sustainable development.	1	SEE/CIA

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	3	SEE/CIA

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	-
CO 4	✓	-	✓	-	-	✓	✓	-	-	-	-	-	-	-	
CO 5	✓	-	✓	-	-	-	✓	-	-	-	-	-	-	✓	-
CO 6	-	✓	-	✓	-	✓	✓	-	-	-	-		-	✓	-

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Recall (knowledge) the basic concepts of power generations in steam power plant **scientific principles** of Methodology, **mathematical principles** and **engineering fundamentals.**	3
CO 2	PO 1	Identify (knowledge) of applied thermodynamics for generation of power from diesel and gas turbine plant **mathematical principles** and **engineering fundamentals.**	2

	PO 2	problem analysis based on first **principles of mathematics** and **engineering sciences** is essential to analyze complex engineering problems based on **data collection** sources of energy **validating** the **experimental design solution**	5
CO 3	PO 2	Make use of the concept of Boundary layer theory for the **Design, Model Creation** and **Validation** of **experimental design** of power electric power plant by **Problem Analysis**	5
	PO 3	Understand the given **problem statement** related to their working principle and based upon type of **experimental design solution.**	2
	PSO 2	Formulate and evaluate concepts of thermo-fluid systems to **provide solutions** for inter disciplinary **engineering applications** for sustainable designs for hydro electric power plant.	2
CO 4	PO 1	Recall (knowledge) the power plant flow measurement, drainage area characteristics **scientific principles** of Methodology, **mathematical principles** and **engineering fundamentals.**	3
	PO 3	Understand the given **problem statement** related to their working principle and based upon type of **hydro electric power plant .**	2
	PO 6	Gained **Knowledge and understanding** of commercial and economic context of various convection problems will help the students to develop hydro electric power plant which is beneficial for the **society**.	2
	PO 7	Students can develop **socio economic** products in pressurized water reactor, boiling water reactor **societal** and **environmental** contexts.	3
CO 5	PO 1	Recall (knowledge) the physical mechanisms involved in nuclear reactor **mathematical principles** and **engineering fundamentals**.	2
	PO 3	Identify the various properties Nuclear fuel, breeding and fertile materials **design, analytical** and **mathematical process.**	3
	PO 7	Students can develop **socio economic** products in a sustainable manner by understanding the impact of radiation hazards and shielding radioactive waste disposal. **societal** and **environmental contexts.**	3
	PSO 2	Formulate and evaluate concepts of thermo-fluid systems to **provide solutions** for inter disciplinary **engineering applications** for sustainable designs for nuclear power stations.	2
CO 6	PO 2	Make use of Power plant economics and environmental considerations **design, model translation** and **validate** and reduce **interpret** Capital cost, investment of fixed charges, operating costs, general arrangement of power distribution.	4

	PO 4	Pollutants and pollution standards, methods of Pollution control which **impact the data** on air quality, climate change, water and land **experimental data**	2
	PO 6	**Gained Knowledge** and **understanding** of commercial and economic context of various convection problems will help the students to develop heat exchangers which are beneficial for the **society.**	2
	PO 7	Students can develop **socio economic** products in a sustainable manner by understanding the impact of the heat exchanging solutions in **societal** and **environmental** contexts.	3
	PSO 2	Formulate and evaluate concepts of thermo-fluid systems to **provide solutions** for inter disciplinary **engineering applications** for sustainable designs for new generation heat exchangers, boilers and heat pipes.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	Program Outcomes/ No. of Key Competencies Matched												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	5	2	-	-	-	-	-	-	-	-	-	-	3	-
CO 4	3	-	2	-	-	2	3	-	-	-	-		-	-	-
CO 5	2	-	3	-	-	-	3	-	-	-	-	-	-	3	-
CO 6	-	5	-	2	-	2	3	-	-	-	-		-	3	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.7	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	50	20	-	-	-	-	-	-	-	-	-	-	100	-
CO 4	100	-	20	-	-	40	66.7	-	-	-	-		-	-	-
CO 5	66.7	-	30	-	-	-	66.7	-	-	-	-	-	-	100	-
CO 6	-	50	-	18.1	-	40	66.7	-	-	-	-		-	100	-

XV COURSE ARTICULATION MATRIX (CO –PO/ PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - $0 \leq C \leq 5\%$ – No correlation

2 - 40 % <C < 60% –Moderate
1-5 <C≤ 40% – Low/ Slight
3 - 60% ≤ C < 100% – Substantial /High

COURSE	**PROGRAM OUTCOMES**												**PSO'S**		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	2	1	-	-	-	-	-	-	-	-	-	-	3	-
CO 4	3	-	1	-	-	2	3	-	-	-	-		-	-	-
CO 5	3	-	1	-	-	-	3	-	-	-	-	-	-	3	-
CO 6	-	2	-	1	-	2	3	-	-	-	-		-	3	-
TOTAL	12	6	3	1	-	4	9	-	-	-	-	-	-	9	-
AVERAGE	3	2	1	1	-	2	3	-	-	-	-	-	-	3	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments	-				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

X	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	INTRODUCTION TO THE SOURCES OF ENERGY
	Introduction to the Sources of Energy: Resources and development of power in india; Steam power plant: Plant layout, Working of different circuits; Fuel and handling equipment, types of coals, coal handling, choice of handling equipment, coal storage, ash handling systems; Combustion process: Properties of coal overfeed and underfeed fuel beds, traveling grate stokers, spreader stokers, retort stokers, pulverized fuel burning system and its components, combustion needs and drought system, cyclone furnace, design and construction, dust collectors, cooling towers and heat rejection, corrosion and feed water treatment.

MODULE II	**INTERNAL COMBUSTION ENGINE PLANT, GAS TURBINE PLANT**
	Internal combustion engine plant: Diesel power plant, introduction, internal combustion engines, types, construction, plant layout with auxiliaries, fuel supply system, air starting equipment, lubrication and cooling system, super charging; Gas turbine plant: Introduction, classification, construction, layout with auxiliaries, principles of working of closed and open cycle gas turbines, combined cycle power plants and comparison; Direct energy conversion: solar energy, fuel cells, thermo electric and thermo ionic, MHD generation.
MODULE III	**HYDRO ELECTRIC POWER PLANT, HYDRO PROJECT AND PLANT**
	Hydro electric power plant: Water power, hydro logical cycle, flow measurement, drainage area characteristics, hydro graphs, storage and Poundage, classification of dams and spill ways; Hydro Projects and Plant: Classification typical layouts, plant auxiliaries, plant operation pumped storage plants; Power from Non-Conventional Sources: Utilization of Solar-collectors; Principle of working, wind Energy, types, HAWT, VAWT tidal energy.
MODULE IV	**NUCLEAR POWER STATION**
	Nuclear Power Station: Nuclear fuel, breeding and fertile materials, nuclear reactor, reactor operation, types of reactors, pressurized water reactor, boiling water reactor, sodium-graphite reactor, fast breeder reactor, homogeneous reactor, gas cooled reactor, radiation hazards and shielding radioactive waste disposal.
MODULE V	**POWER PLANT ECONOMICS AND ENVIRONMENT CONSIDERATION**
	Power plant economics and environmental considerations: Capital cost, investment of fixed charges, operating costs, general arrangement of power distribution, load curves, load duration curve, definitions of connected load, maximum demand, demand factor, average load, load factor, diversity factor, related exercises, effluents from power plants and Impact on environment, pollutants and pollution standards, methods of Pollution control.

TEXTBOOKS

1. Dr. P.C. Sharma, “A Text Book of Power Plant Engineering”, S.K.Kataria, 1st Edition, 2016.

2. I Arora, .S. Domkundwar, “A Course in Power Plant Engineering:”, Dhanapat Rai, 1st Edition, 2014.

REFERENCE BOOKS:

1. I Rajput, “A Text Book of Power Plant Engineering”, Laxmi Publications, 5th Edition, 2014.

2. P. K. Nag, “Power Plant Engineering”, Tata McGraw-Hill, 4th Edition, 2014.

3. G. D. Rai, “An Introduction to Power Plant Technology”, Khanna Publishers, 1st Edition, 2013.

4. C. Elanchezhian, L. Sravan Kumar, B. Vijay Ramnath,"Power plant Engineering", I. K. International Publishers, 1st Edition, 2013.

5. Holman, "Heat Transfer", Tata McGraw-Hill education, 10th Edition, 2019.

6. P. S. Ghoshdastidar, "Heat Transfer", Oxford University Press, 2nd Edition, 2019.

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Discussion on OBE to equip the learning skills of students		
CONTENT DELIVERY (THEORY)			
2	Introduction to the Sources of Energy	CO 1	T2:2.3
3	Resources and development of power in india	CO 1	R1:2.6
4	Steam power plant: Plant layout.	CO 1	T1:2.6
5	Working of different circuits; Fuel and handling equipment.	CO 1	T1:2.6
6	Types of coals, coal handling.	CO 1	T2:2.7, R1:2.18
7	Choice of handling equipment, coal storage, ash handling systems	CO 1	T2:2.22
8	Combustion process: Properties of coal overfeed and underfeed fuel beds.	CO 1	T2:2.25
9	Traveling grate stokers, spreader stokers, retort stokers.	CO 1	T2:2.25
10	Pulverized fuel burning system and its components.	CO 2	T2:2.25
11	Combustion needs and drought system, cyclone furnace.	CO 1	T2:2.26 R1:2.55
12	Design and construction, dust collectors,	CO 2	T2:2.16 R1:2.61
13	Cooling towers and heat rejection, corrosion and feed water treatment.	CO 2	T2:2.16 R1:2.61
14	Internal combustion engine plant: Diesel power plant, introduction	CO 2	T2:2.16 R1:2.61
15	Internal combustion engines, types, construction, plant layout with auxiliaries, fuel supply system, air starting equipment	CO 2	T2:2.30 R1:2.58
16	Lubrication and cooling system, super charging;	CO 2	T2:2.30 R1:2.58
17	Gas turbine plant: Introduction, classification, construction.	CO 2	T2:2.30 R1:2.58
18	Layout with auxiliaries, principles of working of closed and open cycle gas turbines, combined cycle power plants and comparison	CO 3	T2:2.30 R1:2.58
19	Direct energy conversion: solar energy, fuel cells, thermo electric and thermo ionic, MHD generation.	CO 3	T2:3.14 R1:4.31

20	Hydro electric power plant: Water power, hydro logical cycle,	CO 3	T2:3.14 R1:4.31
21	Flow measurement, drainage area characteristics	CO 3	T2:3.14 R1:4.33
22	Hydro graphs, storage and Poundage, classification of dams and spill ways.	CO 3	R1:4.36
23	Hydro Projects and Plant: Classification typical layouts, plant auxiliaries.	CO 3	R1:4.36
24	Power from Non-Conventional Sources.	CO 4	T2:3.18 R1:4.64
25	Utilization of Solar-collector.	CO 4	T2:3.18 R1:4.64
26	Principle of working, wind Energy, types.	CO 4	T2:3.22 R1:4.67
27	HAWT, VAWT tidal energy.	CO 4	T2:3.22 R1:4.67
28	Nuclear Power Station: Nuclear fuel, breeding and fertile materials.	CO 4	T2:3.22 R1:4.67
29	Nuclear reactor, reactor operation,	CO 4	T2:3.28 R1:4.67
30	Types of reactors, pressurized water reactor	CO 5	T2:4.3 R1:4.71
31	Boiling water reactor, sodium-graphite reactor, fast breeder reactor	CO 5	T1:4.8 R2:4.68
32	Homogeneous reactor, gas cooled reactor,	CO 5	T2:4.15 R1:5.74
33	Radiation hazards and shielding radioactive waste disposal	CO 5	T1:4.12 R2:5.75
34	Power plant economics and environmental considerations	CO 5	T1:4.8 R2:5.72
35	Capital cost, investment of fixed charges, operating costs.	CO 5	T1:5.8 R1:5.73
36	General arrangement of power distribution.	CO 5	T1:5.14 R1:6.78
37	General arrangement of load curves, load duration curve.	CO 6	T2:5.19 R1:6.81
38	Definitions of connected load, maximum demand, demand factor, average load, load factor, diversity factor	CO 6	T1:6.4 R2:6.8
39	Homogeneous reactor, gas cooled reactor.	CO 6	T2:7.7 R1:7.74
40	Radiation hazards and shielding radioactive waste disposal.	CO 6	T1:7.12 R2:8.75
41	Capital cost, investment of fixed charges, operating costs, general arrangement of power distribution, load curves, load duration curve	CO 6	T1:7.8 R1:8.72
42	Effluents from power plants.	CO 6	T1:8.8 R3:8.73

43	Effluents from power plants and Impact on environment,	CO 6	T1:9.14 R1:10.78
44	Pollutants and pollution standards, methods of Pollution control.	CO 6	T2:9.19 R1:10.814
45	pollution standards.	CO 6	T2:9.19 R1:10.814
PROBLEM SOLVING/ CASE STUDIES			
1	A power station has the installed capacity of 150 MW. Calculate the cost of generation. Capital cost = Rs.140×106 . Rate of interest and depreciation = 20 oil, salaries and taxation = Rs.30×106 ; Load factor = 42 K_{glass} = 0.75WmK ; k_{air} = 0.02W/mK.	CO 1	T2: 1.1-1.5, T1: 4.1
2	The following data is given for a steam power plant: Maximum Demand 25,000 kW; Load factor 40 efficiency 90station ii) Coal bill of the station for one year	CO 1	R1: 1.1-1.5, T2 : 4.1
3	Draw the schematic diagram of magneto hydrodynamic direct energy conversion power generation unit along with their auxiliary components and discuss the principle.	CO 1	T1: 1.1-1.5, T2 : 4.1
4	Determine the annual cost of a feed water softener from the following data: Cost = Rs 80,000/-, Salvage value = 5cost = Rs 2500/-, Annual cost of chemicals = Rs 5000/-, Labour cost = Rs 300/- per day for two members; Interest on sinking fund = 5 .	CO 2	R2: 1.1-1.5, T1: 4.1
6	The yearly duration curve of a certain plant can be considered as a straight line from 20 MW to 3 MW. To meet this load, three turbine generator units, two rated at 10 MW each and one at 5 MW are installed. Determine i) Installed capacity ii) Plant factor iii) Maximum demand iv) Load factor and v) Utilisation factor.	CO2	T2: 1.1-1.5, T1: 4.1
7	The yearly duration curve of a certain plant can be considered as a straight line from 20 MW to 3 MW. To meet this load, three turbine generator units, two rated at 30 MW each and one at 15 MW are installed. Determine i) Installed capacity ii) Plant factor iii) Maximum demand iv) Load factor and v) Utilisation factor.	CO 3	T2: 1.1-1.5, T1: 4.1
8	The peak load on a power station is 30 MW. The loads having maximum demands of 25 MW, 10MW, 5 MW and 7 MW are connected to the power station. The capacity of the power station is 40MW and annual load factor is 50 power station ii) Energy supplied per year iii) Demand factor iv) Diversity factor.	CO 3	T2: 1.1-1.5, T1: 4.1
9	The following data is given for a steam power plant: Maximum Demand 25,000 kW; Load factor 40 efficiency 90 station ii) Coal bill of the station for one year.	CO 3	R2: 1.1-1.5, T1: 4.1
10	The following data is given for a steam power plant: Maximum Demand 35,000 kW; Load factor 30 efficiency 80 station ii) Coal bill of the station for one year.	CO 4	T2: 1.1-1.5, T1: 4.1
11	The following data is given for a steam power plant: Maximum Demand 15,000 kW; Load factor 20 efficiency 70 station ii) Coal bill of the station for one year.	CO 4	R2: 1.1-1.5, T1: 4.1

12	A generating station supplies the following loads. 15MW, 12MW, 8MW and 0.5 MW. The station has a maximum demand of 20MW and the annual load factor is 0.5. Find the number of units supplied annually and diversity factor.	CO 4	T2: 1.1-1.5, T1: 4.1
13	The following data pertains to a power plant of 120MW capacity. Capital cost = Rs.1500/KW. Interest and depreciation = 10Annual running charges = Rs.20 × 106 Profit to be gained = 10Energy consumed by the Power plant auxiliaries = 5Annual load factor = 0.6 Annual capacity factor = 0.5 Calculate i) The reserve capacity ii) Cost of generation per KW hr.	CO 5, CO 6	T2: 1.1-1.5, T1: 4.1
14	A generating station supplies the load as following. 15MW, 12MW, 8.5 MW, 6MW and 0.45MW. The station has a maximum demand of 22MW. The annual load factor of the station is 0.48. Calculate the number of units supplied annually, the diversity factor and the demand factor.	CO 5, CO 6	R2: 1.1-1.5, T1: 4.1
15	A steam power plant has installed capacity of 120 MW and a maximum demand of 100 MW. The coal consumption is 0.4 kg per kWh and the cost of the coal is Rs 80 per ton. The annual expenses of salaries and other overhead expenses excluding coal are Rs 50 × 105 . The plant works on load factor 0.5 and the capital cost of the power station is Rs 4 × 105 . If the rate of interest and depreciation is 10generation for kWh	CO 5, CO 6	R2: 1.1-1.5, T1: 4.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Introduction to the Sources of Energy: Resources and development of power in india; Steam power plant: Plantlayout, Working of different circuits; Fuel and handling equipment, types of coals, coal handling, choice of handling equipment, coal storage, ash handling systems; Combustion process: Properties of coal overfeed and underfeed fuel beds, traveling grate stokers, spreader stokers, retort stokers, pulverized fuel burning system and its components, combustion needs and drought system, cyclone furnace, design and construction, dust collectors, cooling towers and heat rejection, corrosion and feed water treatment.	CO 1	R4:2.1
2	Internal combustion engine plant: Diesel power plant, introduction, internal combustion engines, types, construction, plant layout with auxiliaries, fuel supply system, air starting equipment, lubrication and cooling system, super charging; Gas turbine plant: Introduction, classification, construction, layout with auxiliaries, principles of working of closed and open cycle gas turbines, combined cycle power plants and comparison; Direct energy conversion: solar energy, fuel cells, thermo electric and thermo ionic, MHD generation.	CO 2	R4:2.1

3	Hydro electric power plant: Water power, hydro logical cycle, flow measurement, drainage area characteristics, hydro graphs, storage and Poundage, classification of dams and spill ways; Hydro Projects and Plant: Classification typical layouts, plant auxiliaries, plant operation pumped storage plants; Power from Non-Conventional Sources: Utilization of Solar-collectors; Principle of working, wind Energy, types, HAWT, VAWT tidal energy.	CO 3, CO 4	R4:2.1
4	Nuclear Power Station: Nuclear fuel, breeding and fertile materials, nuclear reactor, reactor operation, types of reactors, pressurized water reactor, boiling water reactor, sodium-graphite reactor, fast breeder reactor, homogeneous reactor, gas cooled reactor, radiation hazards and shielding radioactive waste disposal.	CO 5	R4:2.1
5	Power plant economics and environmental considerations: Capital cost, investment of fixed charges, operating costs, general arrangement of power distribution, load curves, load duration curve, definitions of connected load, maximum demand, demand factor, average load, load factor, diversity factor, related exercises, effluents from power plants and Impact on environment, pollutants and pollution standards, methods of Pollution control.	CO 6	R4:2.1
DISCUSSION OF QUESTION BANK			
1	Introduction to the source of energy.	CO 1	R4:2.1
2	Internal combustion engine plant, gas turbine plant.	CO 2	T4:7.3
3	Hydro Electric power plant, hydro project and plant.	CO 3,4	R4:5.1
4	Nuclear power plant.	CO 5	T1:7.5
5	Power plant economics and environment consideration.	CO 6	T1: 4.1

Signature of Course Coordinator **HOD, ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**SOFT SKILLS AND INTERPERSONAL COMMUNICATION**				
Course Code	AHSC15				
Program	B.TECH				
Semester	VIII				
Course Type	OPEN ELECTIVE				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3		3	-	-
Course Coordinator	Mr. Washim Sajjad, Assistant Professor				

I COURSE PREREQUISITES

Level	Course Code	Semester	Prerequisites
IB.Tech	AHSC01	I	Basic principles of soft skills and concepts of functional syntacticalities.

II COURSE OVERVIEW

The objectives of Soft Skills and Interpersonal Communication Skills are to give each student a realistic perspective of work and work expectations. It helps formulate problem solving skills and also it guides students in making appropriate responsible decisions. Besides, it creates a desire to fulfill individual goals, and to educate students about productive thinking, self-defeating emotional impulses, and self- defeating behaviors.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Soft skills and Interpersonal communication	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): Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with" either" or" choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
80%	Understand
20%	Apply
0 %	Analyze
0%	Evaluate
0%	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
	Continuous Internal Examination – 2 (Mid-term)	10	
	AAT-1	5	
	AAT-2	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			100

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

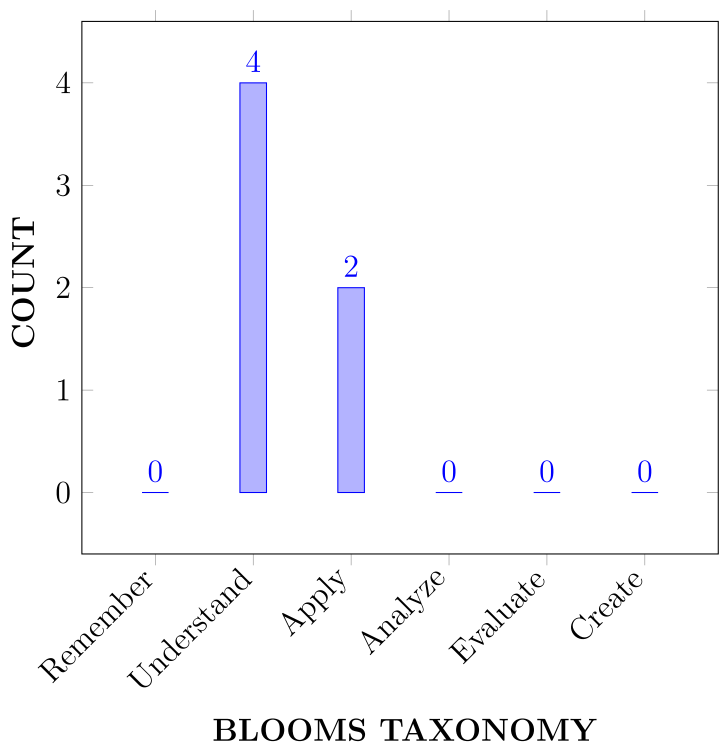
I	Effective communication skills in both spoken and written languages.
II	Well-rounded personalities with a mature outlook, enabling them to function effectively in various formal and informal situations.
III	Self-confidence by mastering inter-personal skills, team management skills, and leadership skills.
IV	Productive presentation skills that provide an advantage when interacting with people at all levels.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Apply** soft skills in the development of personality and use them in their daily life.	Apply
CO 2	**Relate** how to listen actively and respond productively to others.	Understand
CO 3	**Classify** the correct usage of English grammar in reading, writing and speaking.	Understand
CO 4	**Demonstrate** the significance of verbal and non-verbal communication in academic and non-academic platforms.	Understand
CO 5	**Explain** some of the strategies and challenges for developing effective speaking skills and they can be applied to enhance reading skills for understanding the content of advanced-level textbooks and all types of written data.	Understand
CO 6	**Develop** various written communication strategies of cover letter writing, resume writing, E-mail writing and report writing.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO8	**Ethics:**Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (Ethics). 1. **Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior.** 2. **Stood up for what they believed in** 3. **High degree of trust and integrity**	3	Seminar/ Conferences/ Quiz/ AAT Assignments/ Discussion
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. 1. **Clarity (Writing)** 2. **Grammar/Punctuation (Writing)** 3. **References (Writing)** 4. **Speaking (Oral)** 5. **Subject Matter (Oral)**	3	Seminar/ Conferences/ Quiz/ AAT Assignments/ Discussion

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	-	-
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	-	-

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	-	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	-
CO 2	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	✓	-	✓	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	✓	-	✓	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 8	Identify the basic **professional ethics** of ethical choices, codes of ethics, professional practice, and ethical behaviour with special respect to the usage of soft skills and personality development. Besides, students are designed to **stand up for what they believed in** and they are encouraged to maintain a **high degree of trust and integrity.**	3
CO 2	PO 10	Understand the nuances of spoken communication with **clarity**. Recognize correct **grammatical** structures, vocabulary, and language patterns used by proficient speakers, thereby enhancing their own **speaking** proficiency.	5
CO 3	PO 10	Interpret how proper **grammar** contributes to clear communication, both in **written** and **oral** contexts and also demonstrate the apt applicability of different rules of grammar in **oral** presentations with **clarity.**	5
CO 4	PO 8	Infer the essential roles of verbal and nonverbal communication in expressing **ethical choices, discussing codes of ethics, evaluating ethical dimensions, demonstrating ethical behavior, standing up for beliefs, and maintaining trust and integrity within professional contexts.**	3
CO 4	PO10	Extend the knowledge on **subject matter** with appropriate **clarity** using with proper **grammatical** structures in both areas of **speaking** and **written** communication practices.	5

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 5	PO 8	Extend effective speaking skills while applying ethical principles and committing to professional ethics in the field of engineering.	3
CO 5	PO 10	Understand how strong speaking skills play a crucial role in the ability to articulate complex ideas clearly and concisely, enabling effective communication about intricate engineering activities with both the engineering community and society at large.	5
CO 6	PO 10	Classify different **oral** and **written** communication strategies through systematic order and also recognize appropriate method in order to understand the writer's point of view with **clarity** while **reading** and practices proper **grammatical** functionalities to understand different **subject matters.**	5

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-
CO 2	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	3	-	5	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	3	-	5	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-
CO 2	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	100	-	100	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	100	-	100	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-
CO 2	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	3	-	3	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	3	-	3	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
TOTAL								9		15			-	-	-
AVERAGE								3		3			-	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	10 Minutes Video	✓	Open Ended Experiments	✓
Assignments	✓				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback
✓	Early Semester Feedback		

XVIII SYLLABUS:

MODULE I	**SOFT SKILLS**
	Soft Skills: An Introduction – Definition and significance of soft skills; Process, Importance and application of soft skills, discovering the self; setting goals; positivity and motivation: developing positive thinking and attitude
MODULE II	**EFFECTIVENESS OF SOFT SKILLS**
	Developing interpersonal relationships through effective soft skills; Define Listening, Speaking, Reading and Writng skills; Barriers to Listening, Speaking, Reading and Writing; Essential formal writing skills; Public Speaking: Skills, Methods, Strategies and Essential tips for effective public speaking.
MODULE III	**ORAL AND AURAL SKILLS**
	Sounds of English vowels sounds and consonant sounds, Word Accent and connected speech- contractions, questions tags, Listening for information, Taking notes while listening to lectures (use of Dictionary). Group Discussion: Importance, Planning, Elements, Skills, Effectively disagreeing, Initiating

MODULE IV	**VERBAL AND NON-VERBAL COMMUNICATION**
	Interpersonal communication-verbal and nonverbal etiquette; Body language, grapevine, Postures, Gestures, Facial expressions, Proximity; Conversation skills, Critical thinking, Teamwork, Group Discussion, Impact of Stress; Measurement and Management of Stress
MODULE V	**WRITTEN COMMUNICATION**
	Significance; Effectiveness of writing; Organizing principles of Paragraphs in documents; Writing introduction and conclusion; Techniques for writing precisely; Letter writing; Formal and Informal letter writing; E-mail writing, Report Writing.

TEXTBOOKS

1. Raman Meenakshi, Upadhyay Shalini (2017). Soft Skills: Key to Success in Workplace and Life. Cengage India Private Limited, Noida.

2. Handbook of English for Communication (Prepared by Faculty of English, IARE)

REFERENCE BOOKS:

1. Dorch, Patricia. What Are Soft Skills? New York: Execu Dress Publisher, 2013.

2. Klaus, Peggy, Jane Rohman & Molly Hamaker. —The Hard Truth about Soft Skill, London: HarperCollins E-books, 2007.

3. Kamin, Maxine. Soft Skills Revolution: A Guide for Connecting with Compassion for Trainers, Teams, and Leaders. Washington, DC: Pfeiffer & Company, 2013.

4. Stein, Steven J. & Howard E. Book. —The EQ Edge: Emotional Intelligence and Your Success Canada: Wiley & Sons, 2006

5. Suresh Kumar. English for Success. Cambridge University Press IndiaPvt.Ltd.2010.

6. Dorling Kindersley. Communication Skills & Soft Skills - An Integrated Approach. India Pvt. Ltd. 2013.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112105171/1

2. www.edufind.com

3. www.myenglishpages.com

4. http://grammar.ccc.comment.edu

5. http://owl.english.prudue.edu

E-TEXT BOOKS:

1. http://bookboon.com/en/communication-ebooks-zip

2. http://www.bloomsbury-international.com/images/ezone/ebook/writing-skills-pdf.pdf

3. http://learningenglishvocabularygrammar.com/files/idiomsandphraseswith meaningsandexamplespdf.pdf

4. http://www.robinwood.com/Democracy/General Essays/CriticalThinking.pdf

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Discussion on mapping COs with POs (OBE)		T1:06.06
CONTENT DELIVERY (THEORY)			
2	Introduction of soft skills	CO1	T1:06.09
3	Significance of soft skills..	CO1	T1:09.10
4	Process, importance and application of soft skills..	CO1	T1:08:05
5	Discovering one's self-qualities.	CO1	T1:06:02
6	Setting up goals	CO1	T1:04:74
7	Positivity and motivation.	CO1	T1:01:08
8	Developing one's positive thinking and attitude	CO 1	T1:03:01
9	Developing interpersonal relationships through soft skills..	CO2	T1:06:05
10	Significance of listening skills.	CO 2	T1:02:09
11	Significance of speaking skills.	CO 4	T1:26:11
12	Significance of reading skills..	CO 5	T1:46:08
13	Significance of writing skills.	CO 6	T1:16:20
14	Barriers to listening and speaking.	CO 2	T1:13:43
15	Barriers to reading and writing.	CO 5	T1:40:51
16	Essentials of formal writing skills.	CO 6	T1:19:07
17	Developing public speaking skills.	CO4	T1:69:62
18	Methods, strategies of public speaking..	CO 4	T1:5:05
19	Essential tips for effective public speaking.	CO4	T1:46:05
20	Introduction to sounds of vowels and consonants.	CO 4	T1:09:18
21	Contractions and questions tags.	CO 3	T1:07:14
22	Listening for information.	CO 1	T1:32:96
23	Taking notes while listening to lectures.	CO 3	T1:55:21
24	Group discussion and its importance.	CO 2	T1:14:25
25	Planning, elements, skills, effectively, disagreeing, initiating.	CO 2	T1:08:08
26	Developing interpersonal communication skills.	CO4	T1:22:74
27	The role of verbal and nonverbal etiquettes in one's career.	CO1	T1:32:36
28	Significance of body language,	CO 1	T1:78:12
29	Grapevine communication.	CO4	T1:01:08
30	Developing critical thinking.	CO4	T1:04:18
31	Conversation skills at formal and informal situations. .	CO4	T1:06:08
32	The power of group discussion and the role of a team work.	CO4	T1:03:22
33	Impact of stress; measurement and management of stress.	CO4	T1:89:01
34	Significance and effectiveness of writing.	CO 6	T1:01:04
35	Organizing principles of paragraphs in documents;	CO 4	T1:74:32
36	Writing introduction and conclusion	CO 1	T1:25:10
37	Techniques for writing precisely;	CO 6	T1:09:07

38	Letter writing; Formal and Informal letter writing;	CO 6	T1:60:31
39	Rules of E-mail writing.	CO 6	T1:22:12
40	Strategies of report writing.	CO 6	T1:01:01
41	Persuasive writing techniques.	CO 6	T1:01:02
PROBLEM SOLVING/ CASE STUDIES			
42	Soft skills can help someone come out of difficult situations and ensure reassurance along with reliability. think critically and answer	CO 1	R2:7.5
43	Will not hard skills suffice the requirement needed in a corporate setup without soft skills?	CO 1	R2:7.5
44	Do you think soft skills are communication skills? If so, give your reasons	CO 1	R2:7.5
45	Describe the way interpersonal communication can influence the psychological health of individuals with examples.	CO 1	R2:7.5
46	What do you mean by 'assumption' in the communication process and explain with a real -life example?	CO 1	R2:7.5
47	Explain with examples the self-fulfillment and happiness of productive interpersonal communication skills.	CO 1	R2:7.5
48	Explain the importance of learning the sounds of English language for fluent and confident communication.	CO 3	R2:7.5
49	Mispronunciation of English words may lead to miscommunication and misconception. Elaborate with the help of an example.	CO 3	R2:7.5
50	Throw light on word stress which is pivotal for proper differentiation of sounds.	CO 3	R2:7.5
51	Differentiate between verbal and non-verbal communication	CO 4	R2:7.5
52	Classify non-verbal skills and explain the various skills that are important	CO 4	R2:7.5
53	Write down advantages of non-verbal skills	CO 4	R2:7.5
54	What is the meaning of thesis focus? Explain in detail.	CO 6	R2:7.5
55	What do you understand by organization?	CO 6	R2:7.5
56	Support and Elaboration is an extension and development of the topic/subject/ thesis. Comment.	CO 6	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Definition and terminology of soft skills	CO 1	T1:69:08
58	Definition and terminology of contractions	CO 3	T1:65:66
59	Definition and terminology of question tags	CO 3	T1:42:03
60	Definition and terminology of verbal and nonverbal communication	CO 4	T1:78:78
61	Definition and terminology of self discovery	CO 1	T1:09:01

DISCUSSION OF QUESTION BANK			
62	Module I - Soft skills and interpersonal communication	CO 1	R4:2.1
63	Module II - Effectiveness of soft skills	CO 2	T4:7.3
64	Module III - Oral and aural skills	CO 3,4	R4:5.1
65	Module IV - Verbal and nonverbal communication	CO 5	T1:7.5
66	Module V - Interpersonal communication	CO 6	T1: 4.1

Signature of Course Coordinator **HOD**

Mr. Washim Sajjad. Assistant Professor.