INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**MECHANICAL ENGINEERING**				
2	Course Title	**PROFESSIONAL COMMUNICATION**				
3	Course Code	AHSD01				
4	Program	B.Tech				
5	Semester	I Semester				
6	Regulation	BT23				
7	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	0	3	-	-
8	Type of course (**Tick type of course**)		Professional Elective	Open Elective	VAC	MOOCs
			-	-	-	-
9	Course Offered	Odd Semester ✓		Even Semester ×		
10	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: 64		Tutorials: .... Nil		Practical: .... Nil	
11	Course Coordinator	Dr Jan Mohmad Pandit				
12	Date Approved by BOS	24/08/2023				
13	Course Webpage	https://www.iare.ac.in/sites/default/files/BT23/AHSD01.pdf				
14	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**	
		Intermediate	-	-	English Language and Grammar	

15. Course Overview

The principle aim of the course is that the students will get 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.

16. 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	Critical aspect of speaking and reading for interpreting in-depth meaning between the sentences.
IV	Conceptual awareness on writing in terms of unity, content, coherence, and linguistic accuracy.

17. COURSE OUTCOMES:

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

CO 1	**Demonstrate** Demonstrate the prime necessities of listening skills and communication skills for academic and non-academic purposes.	Understand
CO 2	**Comunicate** effectively in spoken English on issues and ideas with a reasonable degree of fluency and accuracy in different social settings.	Understand
CO 3	**Strengthen** acceptable language for developing life skills to overcome the challenges at professional platform.	Understand
CO 4	**Interpret** the grammatical and lexical forms of English and use these forms excellently in specific communicative contexts.	Understand
CO 5	**Articulate** main ideas and important details of literary text at advanced reading levels.	Understand
CO 6	**Extend** writing skills for fulfilling academic and work-place requirements of various written communicative functions.	Understand

18. Topic Learning Outcome (TLOs):

S.No	Topic(s)	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
1	Introduction to communication skils	1	**Interpret** fundamental concepts of communication skills through a procedural approach	CO 1	Understand
		2	**Aware** the techniques of perfect communication within and outside the classroom	CO 1	Understand
		3	**Identify** the parameters of the communication within the classroom as well as outside the classroom.	CO 1	Understand

S.No	**Topic(s)**	**TLO No**	**Topic Learning Outcome's**	**Course Out-come**	Blooms Level
		4	**Practice** ethical communication to embrace a diverse range of individuals, communities, and viewpoints	CO 1	Understand
3	Communication Process	5	**Examine** the process of effective communication at different social situations.	CO 1	Understand
		6	**Articulate** the process of effective communication different social situations	CO 1	Understand
4	Listening Skills	7	**Demonstrate** various kinds of listening setbacks within the classroom.	CO 1	Understand
		8	**Understand** in-depth meaning of audio clips	CO 1	Understand
5	Introduction to phonetics	9	**Familiar** with – and be able to Understand – technical terms for describing and analyzing English pronunciation and be able to read and produce phonemic transcriptions and transcription of intonation patterns.	CO 1	Understand
		10	**Articulate** acceptable language at various academical platforms.	CO 2	Understand
6	Significance of speaking skills	11	**Reinforce** effective oral presentation skillas well as acceptable behavioral traits.	CO 2	Understand
		12	**Maintain** global civic attitude at work place and feel as a responsible citizen.	CO 2	Understand
		13	**Plan** as a professional speaker before going to deliver an academic presentation.	CO 2	Understand
7	Generating talks based on visual prompts	14	**Get** consciousness about the importance of using flash cards, handouts and images to have an effective comprehension.	CO 2	Understand
8	Oral presentation using power point slides	15	**Understand** properly making effective PPTs in order to give a successful presentation.	CO 2	Understand
9	Delivering speech effectively	16	**Anticipate** problems with discussion groups	CO 2	Understand
10	Essentials of speaking skills	17	**Show** acceptable attitude at learning place as well as at work place.	CO 3	Understand
11	Exposure to structured talks	18	**Pay** appropriate attention as a learner of English as a second language.	CO 3	Understand
12	The concept of word formation	19	**Enhance** lexical ability to experience of IELTS, TOEFL, GRE tests.	CO 4	Understand

S.No	Topic(s)	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
13	Idioms and phrases	20	**Recognize** and understand the meaning of idioms and phrases.	CO 4	Understand
		21	**Able** to create own idiom story using story jumper	CO 4	Understand
14	Sentence structure	22	**Able** to write syntactical organization of given functions in non-periodic interval	CO 4	Understand
15	Usage of punctuation marks	23	**Understand** well using proper punctuation tools to deliver the topic successfully.	CO 4	Understand
16	Advanced level prepositions	24	**Identify** and define prepositions, prepositional phrases and objects of the preposition.	CO 4	Understand
17	Tenses	25	**Use** tenses syetematically to deliver the message without the ambiguity.	CO 4	Understand
18	Subject verb agreement	26	**Learn** the most common rules for subject/verb agreement and also identify proper and improper subject / verb agreement in the peer writing.	CO 4	Understand
19	Degrees of comparison	27	**Able** to use the positive, comparative, and superlative degrees of the regular and irregular adjectives and adverbs.	CO 4	Understand
20	Direct and indirect speech	28	**Define** direct speech and indirect speech and distinguish between direct and indirect speech and classify the rules for converting direct speech to indirect speech and indirect speech to direct speech.	CO 4	Understand
21	Questions tags.	29	**Use** the correct polarity (positive or negative), depending on the polarity of the statement.	CO 4	Understand
22	Significance of reading skills	30	**Accelerate** the ability of reading comprehension in advanced learning	CO 5	Understand
23	Techniques of reading	31	**Know** Vrious parameters of reading skills	CO 5	Understand
		32	**Use** different literary reading tools to establish his/her argument effectively.	CO 5	Understand
		33	**Extends** consolidates and sustains vocabulary growth	CO 5	Understand
24	Significance of writing skills	34	**Aware** the importance of writing skills particuarly at academic domain	CO 6	Understand
25	Effectiveness of writing	35	**Understand** well using proper writing tools to deliver his/her thesis	CO 6	Understand

S.No	Topic(s)	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
26	The role of a topic sentence and supporting sentences in a paragraph	36	**Write** effective topic sentence as well as supporting sentences to convey a message to his/her readers/audience.	CO 6	Understand
27	Organizing principles of paragraphs in a document	37	**Generate** fa paragraph effectively using prime principles	CO 6	Understand
		38	**Describe** the principles of paragraph writing and properities of paragraphs	CO 6	Understand
29	Report writing	39	**Present** an original thesis on a significant topic within a well defined subject area	CO 6	Understand
30	E-mail writing	40	**Use** effectively technical writing tools at workplace	CO 6	Understand
31	Various formats for letter writing	41	**Knows** how to concise a written text without changing the core idea	CO 6	Understand

19. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
Subject: Employment advantage: Effective English language and communication skills are crucial in many aspects of life, including education, business, workplace and social interactions. Proficient English language skills enable individuals to express themselves clearly, understand others, and engage in meaningful conversations. As the primary language of communication across the globe, proficiency in English is a highly sought-after skill in the international workplace and one of the benefits of learning English is therefore that it significantly boosts our job opportunities.

20. Content Delivery / Instructional Methologies:

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

21. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Table 4: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

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 12 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
35%	Understand
55%	Apply

22. SYLLABUS:

MODULE I	**GENERAL INTRODUCTION AND LISTENING SKILLS | Number of Lectures: 13**
	Introduction to communication skills; communication process; elements of communication; listening skills; significance of listening skills; stages of listening; barriers and effectiveness of listening; Introduction to phonetics; listening comprehension.
MODULE II	**SPEAKING SKILL | Number of Lectures: 13**
	Significance of speaking skills; essentials of speaking skills; verbal and non-verbal communication; generating talks based on visual prompts; public speaking; exposure to structured talks; delivering speech effectively; oral presentation using power point slides; soft skills and hard skills; importance of soft skills for engineers.

MODULE III	**VOCABULARY AND GRAMMAR** **. |Number of Lectures: 13**
	The concept of word formation; idioms and phrases; one-word substitutes, sentence structure (simple, compound and complex); usage of punctuation marks; advanced level prepositions; tenses; subject verb agreement; degrees of comparison; direct and indirect speech; questions tags.
MODULE IV	**READING SKILL | Number of Lectures: 12**
	Significance of reading skills, techniques of reading, skimming-reading for the gist of a text, scanning–reading for specific information, intensive, extensive reading, reading comprehension, metaphor and figurative language.
MODULE V	**WRITING SKILL | Number of Lectures: 13**
	Significance of writing skills; effectiveness of writing; the role of a topic sentence and supporting sentences in a paragraph; organizing principles of paragraphs in a document; writing introduction and conclusion; techniques for writing precis, various formats for letter writing (block format, full block format, and semi bloc format); e-mail writing, report writing.

TEXTBOOKS

1. 1. Anjana Tiwari, "*Communication Skills in English,* ", Khanna Publishing House: New Delhi, 2022.

REFERENCE BOOKS:

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

MATERIALS ONLINE:

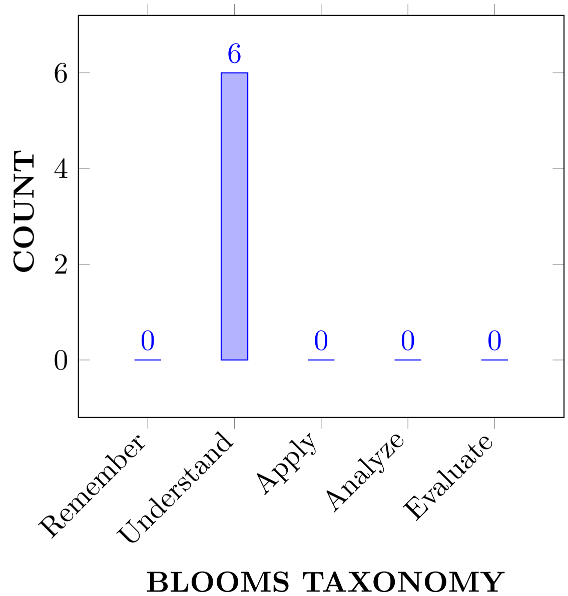
1. Lecture notes, ELRV videos and power point presentations

2. Answers / solutions to all questions / problems in the textbook

3. Online exercises

4. Problems and solutions in files

23. COURSE KNOWLEDGE COMPETENCY LEVEL



24. COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
1	Introduction to communication skills	CO 1	T1; R1
2	Communication process	CO 1	T1; R1
3	Elements of communication	CO 1	T1; R1
4	Significance of listening skills	CO 1	T1; R1
5	Different stages of listening	CO 1	T1, R1
6	Different stages of listening	CO 1	T1, R1
7	Listening comprehension	CO 1	T1, R1
8	Introduction to phonetics	CO 1	T1, R1
9	Significance of speaking skills	CO 2	T1, R1
10	Essentials of speaking skills	CO 2	T1, R1
11	Verbal and non-verbal communication	CO 2	T1; R1, R2
12	Generating talks based on visual prompts	CO 2	T1; R1, R2
13	Public speaking	CO 1	T1; R1, R2
14	Exposure to structured talks	CO 2	T1; R1, R2
15	Oral presentation using power-point slides	CO 2	T1; R1, R2
16	Soft skills and hard skills	CO 3	T1; R1, R2
17	Importance of soft skills for engineers	CO 3	T1; R1, R2

S.No	Topics to be covered	CO's	Reference
18	Concept of word formation	CO	T1; R1, R2
19	Idioms and phrases	CO 4	T1; R3, R4
20	One-word substitutes	CO 4	T1; R3, R4
21	Sentence structure	CO 4	T1; R3, R4
22	Usage of punctuation marks	CO 4	T1; R3, R4
23	Advanced level prepositions	CO 4	T1; R3, R4
24	Functions of tenses	CO 4	T1; R3, R4
25	Subject verb agreement	CO 4	T1; R3, R4
26	Degrees of comparison	CO 4	T1; R1, R2
27	Direct and indirect speech	CO 4	T1; R1
28	Question tags	CO 4	T1; R1
29	Significance of reading skills	CO 5	T1; R1
30	Techniques of reading	CO 5	T1; R1
31	Skimming and Scanning	CO 5	T1; R1
32	Intensive and extensive reading	CO 5	T1; R1
33	Significance of writing skills	CO 6	T1; R1
34	Effectiveness of writing	CO 6	T1; R1
35	The role of a topic sentence	CO 6	T1; R1
36	Supporting sentences to develop a paragraph	CO 6	T1; R1
37	Organizing principles of paragraphs in a document	CO 6	T1; R4
38	Writing introduction and conclusion	CO 6	T1; R4
39	Metaphor and figurative language	CO 6	T1; R4
40	Technicalities of writing precis, Letter, e-mail, report and Various formats for letter writing	CO 6	T1; R4
PROBLEM SOLVING/ CASE STUDIES			
1	The aspects to improve listening comprehension Discuss in detail.	CO 1	TI:10,11
2	Different types of listeners with examples.	CO 1	TI: 19,21
3	The sounds of English language.	CO 1	TI:23,27
4	verbal communication or written communication.	CO 2	TI: 27,30
5	Various difficulties in public speaking.	CO 2	TI: 32,33
6	Different ways of greeting people in formal and informal situation and discuss how do they matter in communication?	CO 2	TI: 35,37
7	'Oral presentation requires a good planning'.	CO 2	TI:36,38
8	Power point presentation and the ways to make Power point presentation.	CO 3	TI: 37,38
9	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
10	The usage of idioms and phrases in spoken English.	CO 4	TI: 47,50
11	'Structure proposition-evaluation' -Reading technique.	CO 5	TI:56,58

S.No	Topics to be covered	CO's	Reference
12	Active reading, detailed reading, and speed-reading techniques used in different situations.	CO 5	TI: 79,81
13	The elements of paragraph writing in detail.	CO 6	TI:100,102
14	Logical bridges and Verbal bridges in writing.	CO 6	TI: 102,104
15	The role of topic sentence to develop a paragraph.	CO 6	TI:105, 115
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Soft skills and Interpersonal Communication	CO 3	TI 8,9
2	Language acquisition is a process.	CO 2, CO3	TI: 11,12
3	Communication.	CO 3, CO 4	TI: 20, 25
4	Time management.	CO 5	TI: 36, 42
5	Stress management.	CO 3	T: 55, 68
DISCUSSION OF TUTORIAL QUESTION BANK			
1	Soft Skills for difficult situations in terms of reassurance and reliability.	CO 3	TI
2	Verbal and non-verbal communication.	CO 3	TI
3	Honesty, Respect, Self-Control and Accountability their role in building long lasting interpersonal skills?	CO 3	TI
4	Etiquette and manners. Its importance in social, personal and professional communication.	CO 3	TI
5	Problem solving and decision making.	CO 3	TI

25. PROGRAM OUTCOMES & PROGRAM SPECIFIC 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
Program Specific Outcomes	
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.

26. 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. 1. Clarity (Writing); 2. Grammar/Punctuation (Writing); 3. References (Writing); 4. Speaking Style (Oral); 5. Subject Matter (Oral).	5	CIE/Quiz/AAT

27. 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

28. 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	-	-	-	-	-	-	-	-	-	✓	-		-	-	-

29. 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 10	Apply the mathematics, science and Engineering fundamentals to problems involving frictional force additionally in system of forces using the knowledge of mathematics and science fundamentals.	5
CO 3	PO 10	Apply the mathematics, science and Engineering fundamentals for locating centroid and centre of gravity using the knowledge of mathematics and science fundamentals.	5

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 4	PO 10	Interpret the grammatical knowledge and punctuation marks systematically towards providing clarity in speaking and writing.	5
CO 5	PO 10	Demonstrate the role of grammar and punctuation marks to understand the meaning between the sentences as well as paragraphs in speaking or writing for clarity.	5
CO 6	PO 10	Describe the clarity of grammatical usage and the obligation of punctuation marks in speaking and writing.	5

30. 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	-	-	-	-	-

31. 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	-	-	-	-	-

32. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

2 - 40 % $<C<$ 60% –Moderate

1-5 $<C \leq$ 40% – Low/ Slight

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

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

33. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓				

34. ASSESSMENT METHODOLOGY INDIRECT:

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

35. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1		
2		
3		

4	QUALITY EDUCATION	English language has become linguafranca across the globe. For that reason, it is compelsory to learn this language at advanced level. In MNC commpanies, those who have excellent communication skills ,their carrer graph goes to the higher level very quickly. Hence ,the role of English language has become a part of the life.
5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	
7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	
10	REDUCED INEQUALITIES	

11	 SUSTAINABLE CITIES AND COMMUNITIES	
12	 RESPONSIBLE CONSUMPTION AND PRODUCTION	
13	 CLIMATE ACTION	
14	 LIFE BELOW WATER	
15	 LIFE ON LAND	

16	PEACE, JUSTICE AND STRONG INSTITUTIONS	
17	PARTNERSHIPS FOR THE GOALS	

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD**
Dr Jan Mohmad Pandit, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**MECHANICAL ENGINEERING**				
2	Course Title	**MATRICES AND CALCULUS**				
3	Course Code	AHSD02				
4	Program	B.Tech				
5	Semester	I Semester				
6	Regulation	BT23				
7	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	1	4	-	-
8	Type of course (**Tick type of course**)	Core ✓	Professional Elective -	Open Elective -	VAC -	MOOCs -
9	Course Offered	Odd Semester ✓		Even Semester ×		
10	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: 48 hours		Tutorials: 16 hours		Practical: 0 hours	
11	Course Coordinator	Mr. P. Shantan Kumar				
	Course Instructor	Ms L. Indira				
12	Date Approved by BOS	23 August 2023				
13	Course Webpage	https://www.iare.ac.in/sites/default/files/BT23/AHSD02.pdf				
14	Course Prerequistes -	**Level**	**Course Code**	**Semester**	**Prerequisites**	
		10+2	-	-	Basic Principles of Algebra and Calculus	

15. Course Overview

This course is a foundation for all engineering branches. It includes concepts of Matrices, Eigen Values, Eigen Vectors, Functions of Single, Several Variables, Fourier Series and Multiple Integrals. This course is applicable for simulation, colour imaging processing and optimal solutions in all engineering problems.

16. Course Objectives:

The students will try to learn:

I	The Concept of the rank of a matrix, eigen values, eigen vectors and solution of the system of linear equations.
II	The Geometrical approach to the mean value theorems and applications.
III	The Fourier series expansion in periodic and non-periodic intervals.
IV	The Evaluation of multiple integrals and applications.

17. Course Outcomes:

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

CO 1	**Determine** the rank and solutions of linear equations with elementary operations.
CO 2	**Utilize** the Eigen values, Eigen vectors for developing spectral matrices.
CO 3	**Make use of** Cayley-Hamilton theorem for finding powers of the matrix.
CO 4	**Interpret** the maxima and minima of given functions.
CO 5	**Apply** the Fourier series expansion of periodic functions for harmonic series.
CO 6	**Determine** the volume of solid bounded regions by using the integral calculus.

18. Topic Learning Outcome (TLOs):

S.No	**Topic(s)**	**TLO No**	**Topic Learning Outcome's**	**Course Outcome**	Blooms Level
1	Rank of a matrix	1	**Calculate** the rank of a matrix by using determinants	CO 1	Apply
		2	**Calculate** the rank of a matrix by using elementary operations	CO 1	Apply
2	Inverse of a matrix by Gauss-Jordan method	3	**Compute** the inverse of the given matrix by elementary operations	CO 1	Apply
3	System of non-homogeneous equations	4	**Identify** the use of matrix theory to solve the system of linear equations in various engineering problems	CO 1	Apply
		5	**Examine** the system of homogeneous equations by its augmented form	CO 1	Apply
		6	**Examine** the system of non homogeneous equations for its augmented form	CO 1	Apply
4	Characteristic equation	7	**Recall** the concepts of characteristic equations of matrices	CO 2	Remember
5	Eigenvalues and Eigenvectors	8	**Recall** the concepts of eigenvalues for future engineering applications	CO 2	Remember
		9	**Recall** the concepts of eigenvectors for future engineering applications	CO 2	Remember

S.No	Topic(s)	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
		10	**Utilize** the characteristic polynomials to compute the eigenvalues and eigenvectors	CO 3	Apply
6	Cayley-Hamilton theorem, Diagonalization of a matrix	11	**Make use of** the Cayley-Hamilton to find inverse of a matrix	CO 3	Apply
		12	**Make use of** the Cayley-Hamilton to find powers of a matrix	CO 3	Apply
		13	**Make use of** the Cayley-Hamilton to find diagonalization of a matrix	CO 3	Apply
7	Continuous functions	14	**Explain** the geometrical interpretation of continuous functions on closed and bounded intervals	CO 4	Understand
8	Mean value theorems	15	**Interpret** the mean value theorems on bounded functions	CO 4	Understand
9	Partial differentiation	16	**Recall** the partial differentiation for the functions of several variables	CO 4	Remember
10	Jacobian transformations	17	**Make use of** Jacobian transformations for the functions are to be dependent or independent	CO 4	Apply
11	Maxima and minima of a function	18	**Identify** the maxima and minima of a function with several variables by using partial derivatives	CO 4	Apply
12	Euler coefficients	19	**State** the Euler coefficients for Fourier expansion of periodic functions in a given interval	CO 5	Remember
13	Fourier series in periodic interval	20	**Extend** the Fourier series of given functions in a given periodic interval $(-\pi, \pi)$	CO 5	Understand
		21	**Extend** the Fourier series of given functions in a given periodic interval $(0,2\pi)$	CO 5	Understand
14	Fourier series in non -periodic intervall	22	**Compute** the Fourier series of given functions in non-periodic interval (0,2l)	CO 5	Apply
15	Half- range Fourier series	23	**Extend** the half- range Fourier series expansions of a function in a given periodic interval $(0,\pi)$	CO 5	Apply
		24	**Extend** the half- range Fourier series expansions of a function in a given arbitrary interval (0, l)	CO 5	Apply

S.No	Topic(s)	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
16	Double integrals	25	**Solve** the double integrals of functions in given constant limits	CO 6	Apply
		26	**Solve** the double integrals of functions in cartesian coordinates with given limits	CO 6	Apply
		27	**Solve** the double integrals of functions in polar coordinates with given limits	CO 6	Apply
17	Change order of integration	28	**Identify** the change order of integration of double integrals in cartesian form	CO 6	Remember
18	Triple integrals	29	**Calculate** the triple integrals of function in given constant limits	CO 6	Apply
		30	**Calculate** the triple integrals of function in cartesian coordinates with given limits	CO 6	Apply

19. Employability Skills

1. **Linear Algebra:** Employability/ Skill development: Apply the concepts of Linear Algebra in programming languages
2. **Matrices and Differential Calculus:** Employability/ Skill development: Uses the basic of matrices and Calculus calculation concept in the field of Engineering
3. **Integral Calculus:** Employability/ Skill development: Uses the concept of definite integral in engineering problems
4. **Multivariable calculus:** Employability/ Skill development: Can solve the different Multivariable calculus

20. Content Delivery / Instructional Methologies:

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

21. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Semester End Examination (SEE): The SEE is conducted for 60 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. No choice is given from first two modules. Each question carries 12 marks. There could be a maximum of two sub divisions in a question.

Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE :

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

22. Course content - Number of modules: Five

MODULE I	**MATRICES** | **Number of Lectures: 09**
	Rank of a matrix by echelon form and normal form; inverse of non-singular matrices by Gauss-Jordan method; system of linear equations: solving system of homogeneous and non-homogeneous equations.
MODULE II	**EIGEN VALUES AND EIGEN VECTORS** | **Number of Lectures: 10**
	Eigen values; Eigen vectors and their properties (without proof); Cayley-Hamilton theorem (without proof), verification; finding inverse and power of a matrix by Cayley-Hamilton theorem; diagonalization of a matrix.
MODULE III	**FUNCTIONS OF SINGLE AND SEVERAL VARIABLES .** | **Number of Lectures: 10**
	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 of two variables and three variables; method of Lagrange multipliers.
MODULE IV	**FOURIER SERIES** | **Number of Lectures: 09**
	Fourier expansion of periodic function in a given interval of length 2π; Fourier series of even and odd functions; Fourier series in an arbitrary interval; half-range Fourier sine and cosine expansions.
MODULE V	**MULTIPLE INTEGRALS** | **Number of Lectures: 10**
	Evaluation of double integrals (cartesian and polar coordinates); change of order of integration (only cartesian coordinates); evaluation of triple integrals (cartesian coordinates).

Text Books

1. B. S. Grewal, "*Higher Engineering Mathematics*", Khanna Publishers, 44/e, 2017.

2. Erwin Kreyszig, "*Advanced Engineering Mathematics*", John Wiley & Sons, 10/e, 2011.

ReferenceE Books:

1. R. K. Jain and S. R. K. Iyengar, "*Advanced Engineering Mathematics*", 3/ed Narosa Publications, 5th Edition , 2016.
2. George B. Thomas, Maurice D. Weir and Joel Hass, Thomas,, "*Calculus*", Uma Publications, 13/e Edition,Pearson Publishers, 2013.
3. N.P. Bali and Manish Goyall "*A text book of Engineering Mathematics*", Laxmi Publication, Reprint, 2008.
4. Dean G. Duffy, "*Advanced Engineering Mathematics with MATLAB*", PCRC Press
5. Peter O'Neil, "*Advanced Engineering Mathematics*", Cengage Learning.
6. B.V. Ramana, "*Higher Engineering Mathematics*", McGraw Hill Education

Electronic Resources:

1. https://onlinecourses.nptel.ac.in/noc23_ma88/preview
2. https://onlinecourses.nptel.ac.in/noc23_ma86/preview
3. https://www.efunda.com/math/math_home/math.cfm
4. https://www.ocw.mit.edu/resourcs/#Mathematics
5. https://www.sosmath.com
6. https://www.mathworld.wolfram.com

Materials Online:

1. Course template
2. Tech-talk topics
3. Assignments
4. Definition and terminology
5. Tutorial question bank
6. Model question paper – I
7. Model question paper – II
8. Lecture notes
9. Early lecture readiness videos (ELRV)
10. Power point presentations

23. COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
1	Theory of Matrices: Types of Real Matrices	CO 1	T1:2.4 R3:3.11
2	Elementary Operations: Elementary Row and Column Transformations	CO 1	T1:2.7.2 R3:3.34
3	Rank of a Matrix by Echelon Form	CO 1	T1:2.7.4 R3:3.38
4	Rank of a Matrix by Normal Form	CO 1	T1:2.7.7 R3:3.38
5	Inverse of a Matrix by Gauss-Jordan Method	CO 1	T1:2.7.6 R3:3.37
6	Solving system of Non-Homogeneous equations	CO 1	T1:2.10.1 R3:3.39
7	Solving system of Homogeneous equations	CO 1	T1:2.10.3 R3:3.39
8	Solving system of Non Homogeneous equations(Unknown Values)	CO 1	T1:2.10.3 R3:3.39
9	Eigen Values of a Matrix	CO 2	T1:2.13.1 R3:3.46
10	Eigen Vectors of a Matrix	CO 2	T1:2.13.2 R3:3.47
11	Properties of Eigen values and Eigen Vectors of a Matrix Problems	CO 2	T1:2.14 R3:3.47
12	Cayley-Hamilton Theorem- Statement, Verification	CO 3	T1:2.15 R3:3.48
13	Applications of Cayley – Hamilton: Finding Inverse and Powers of a Matrix	CO 3	T1:2.15 R3:3.48
14	Diagonalization of Matrix by Linear Transformation	CO 3	T1:2.16.1 R3:3.49
15	Linear Dependence and Independence of Vectors	CO 3	T1:2.3 R3:3.2
16	Mean Value Theorems:1: Rolle's Theorem	CO 4	T1:4.3.1 R6:2.1
17	Mean Value Theorems:2: Lagrange's Theorem	CO 4	T1:4.3.2 R6:2.2
18	Mean Value Theorems:3: Cauchy's Theorem	CO 4	T1:4.3.3 R6:2.3

S.No	Topics to be covered	CO's	Reference
19	Functions of Several Variables: Partial Differentiation	CO 4	T1:5.2 R3:5.1
20	Jacobian Transformations	CO 4	T1:5.7.1 R3:5.10
21	Functional Dependence	CO 4	T1-5.7.4 R3:5.11
22	Maxima and Minima of Functions with Two Variables	CO 4	T1:5.11.1 R3:5.13
23	Maxima and Minima of Functions with Three Variables	CO 4	T1-5.11.1 R3:5.14
24	Method of Lagrange Multipliers	CO 4	T1-5.12 R3:5.15
25	Euler Coefficeients for Fourier Expansion of Periodic Function in a Given Interval of Length (-π,π),(0,2π)	CO 5	T1-10.2 R3:10.3
26	Fourier Series of Even Functions in a Given Interval of Length $(-\pi,\pi)$	CO 5	T1-10.6.1 R3:10.3
27	Fourier Series of Odd Functions in a Given Interval of Length $(-\pi,\pi)$	CO 5	T1-10.6.2 R3:10.3
28	Fourier Series of Neither Functions in a Given Interval of Length $(-\pi,\pi)$	CO 5	T1-10.6.2 R3:10.3
29	Fourier Series in an Arbitrary Interval (0,2l)	CO 5	T1-10.6.1 R3:10.6
30	Fourier Series in an Arbitrary Interval (-l,l)	CO 5	T1-10.6.2 R3:10.6
31	Half- Range Fourier Sine Expansions in a Given Interval of Length (0,π)	CO 5	T1-10.7 R3:10.7
32	Half- Range Fourier Cosine Expansions in a Given Interval of Length (0,π)	CO 5	T1-10.7 R3:10.7
33	Double Integrals in Constant Limits	CO 6	T1-7.1 R3:6.1
34	Double Integrals in Variable Limits	CO 6	T1-7.1 R3:6.2
35	Double Integrals in cartesian coordinates (Area enclosed by plane curves)	CO 6	T1-7.4 R3:6.2
36	Double Integrals in polar coordinates	CO 6	T1-7.3 R3:6.3
37	Change of order of integration (only Cartesian form)	CO 6	T1-7.2 R3:6.4
38	Triple Integrals in Constant Limits	CO 6	T1-7.5 R3:6.5
39	Triple Integrals in Variable Limits	CO 6	T1-7.5 R3:6.5

S.No	Topics to be covered	CO's	Reference
40	Double and Triple Integrals	CO 6	T1-7.1 R3:6.5
PROBLEM SOLVING/ CASE STUDIES			
1	Rank of the Matrix by Echelon and Normal Form	CO 1	T1-2.7 R3:3.38
2	Homogeneous and Non Homogeneous Equations	CO 1	T1-2.10 R3:3.39
3	Eigen Values and Eigen Vectors of the Matrix	CO 2	T1-2.13 R3:3.46
4	Eigen Values and Eigen Vectors of the Matrix	CO 2	T1-2.16 R3:3.49
5	Cayley Hamilton Theorem Problems	CO 3	T1-2.15 R3:3.48
6	Powers of the Matrix by Cayley Hamilton Theorem	CO 3	T1-2.15 R3:3.48
7	Powers of the Matrix by Cayley Hamilton Theorem	CO 4	T1-4.3 R6:2.1
8	Jacobians, Functional Relationship	CO 4	T1-5.7 R3:5.10
9	Maxima and minima problems	CO 4	T1-5.11 R3:5.13
10	Fourier Series expansion of Periodic Function in a Given Interval of Length 2π	CO 5	T1-10.2 R3:10.3
11	Fourier Expansion of Periodic Function in a Given Interval of Length $(-\pi, \pi)$	CO 5	T1-10.6 R3:10.3
12	Fourier Series in an Arbitrary Interval (-l,l), Fourier Sine, Cosine Series in Interval (0,l)	CO 5	T1-10.6 R3:10.6
13	Finding Double Integrals in Cartesian and Polar Coordinates	CO 6	T1:7.1 R3:6.1
14	Change of order of integration	CO 6	T1-7.2 R3:6.4
15	Triple Integrals	CO 6	T1-7.5 R3:6.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Rank of a Matrix, Homogeneous and Non-Homogeneous equations	CO 1	T1-2.7 R3:3.39
2	Eigen Values and Eigen Vectors, Diagonalization	CO 2, CO3	T1-2.13 R3:3.46
3	Mean Value Theorems, Jacobian Transformations, Functionally Dependent and Independent	CO 4	T1-4.3 R6:2.1
4	Fourier Series (Even, Odd, Neither Functions)	CO 5	T1-10.2 R3:10.3

S.No	Topics to be covered	CO's	Reference
5	Multiple Integrals (Double and Triple)	CO 6	T1-7.1 R3:3.6.1
DISCUSSION OF TUTORIAL QUESTION BANK			
1	Matrices	CO 1	T1-2.4 R3:3.11
2	Eigen Values and Eigen Vectors	CO 2, CO 3	T1-2.13 R3:3.46
3	Functions of Several Variables	CO 4	T1-5.2 R3:5.1
4	Fourier Series	CO 5	T1-10.2 R3:10.3
5	Multiple Integrals	CO 6	T1-7.1 R3:6.1

24. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

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

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

25. 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

26. 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

27. 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	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-

28. 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 modelled by matrices with help of Characteristic 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 modelled by matrices (principles of mathematics).	2
CO 4	PO 1	Explain the mean–value theorems for the single variable functions and the extreme values for functions of several variables apply them in the complex engineering problems Partial derivatives of (principles of mathematics).	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 5	PO 1	Build the Fourier series expansion for the complex engineering problems modelled 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
CO 6	PO 1	Determine the solution of complex engineering problems modelled by Double and Triple Integrals by using substitution method and principles of mathematics.	2
	PO 2	Model the problem with the help of ordinary integrations, prepare precise statement of the problem and apply on double and triple integrations by method of ordinary integration and other analytical methods to develop the solution and interpret, validate the results through proper documentation.	6

29. TOTAL COUNT 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	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-

30. 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	60	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.6	60	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.6	60	-	-	-	-	-	-	-	-	-	-	-	-	-

31. 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≤ 40% – Low/ Slight

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

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

32. ASSESSMENT METHODOLOGY DIRECT:

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

33. ASSESSMENT METHODOLOGY INDIRECT:

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

34. Relevance to Sustainability goals:

Brief description about the course and how its relevance to SDGs.

Mathematics plays an important role in the achievement of the Sustainable Development Goals (SDG) and at the same time these allow working with real situations in the subject of mathematics, providing the student with active learning. Sustainability is used to make the student see the usefulness of mathematics while instilling values and attitudes towards it.

×	NO POVERTY	-
×	ZERO HUNGER	-
×	GOOD HEALTH AND WELL-BEING	-
✓	QUALITY EDUCATION	**Quality Education:** Minimizing school dropout: The teaching of mathematics plays an important role in the implementation of sustainable education to achieve future goals: to make learning mathematics more relevant and applicable, as well as to support the development of 21st century skills.
×	GENDER EQUALITY	-
×	CLEAN WATER AND SANITATION	-
×	AFFORDABLE AND CLEAN ENERGY	-
×	DECENT WORK AND ECONOMIC GROWTH	-
×	INDUSTRY, INNOVATION AND INFRASTRUCTURE	-
×	REDUCED INEQUALITIES	-
×	SUSTAINABLE CITIES AND COMMUNITIES	-

×	RESPONSIBLE CONSUMPTION AND PRODUCTION	-
×	CLIMATE ACTION	-
×	LIFE BELOW WATER	-
×	LIFE ON LAND	-
×	PEACE, JUSTICE AND STRONG INSTITUTIONS	-
×	PARTNERSHIPS FOR THE GOALS	-

Approved by: Board of Studies in the meeting conducted on ——————————.

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

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**MECHANICAL ENGINEERING**				
2	Course Title	**Elements of Electrical and Electronics Engineering**				
3	Course Code	AEED01				
4	Class/ Semester	I/ I				
5	Regulation	BT-23				
6	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	-	3	-	-
7	Type of course (**Tick type of course**)	Core	Professional Elective	Open Elective	VAC	MOOCs
		✓	-	-	-	-
8	Course Offered	Odd Semester ✓		Even Semester ×		
9	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: 48 hours		Tutorials: *Nil* hours		Practical: *Nil* hours	
10	Course Coordinator	Mr.G.Viswanath				
11	Date Approved by BOS	24/08/2023				
12	Course Webpage	www.iare.ac.in/—-/—-				
13	Course Prerequistes	**Level**	**Course Code**	**Course title**	**Semester**	
	-	-	-	-	-	

14. Course Overview

The course provides basic foundation in electrical and electronics. It includes the concepts related to electrical circuits, the fundamental operating principles of electrical machines and the characteristics of semiconductor devices. It also empowers students to understand electronics and electrical systems in their daily lives, from household appliances to personal devices.

15. COURSE OBJECTIVES:

The students will try to learn:

I	The fundamentals of electrical circuits and analysis of circuits with DC and AC excitation using circuit laws.
II	The construction and operation of Electrical machines..
III	The operational characteristics of semiconductor devices with their applications. .

16. COURSE OUTCOMES:

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

CO 1	Make use ofbasic electrical laws for solving DC and AC circuits.	Understand
CO 2	Solve the network theorems to calculate the parameters in electrical circuits.	Understand
CO 3	Demonstrate the fundamentals of electromagnetism for the operation of DC and AC machines.	Uderstand
CO 4	Utilize the characteristics of diodes for the construction of rectifiers and regulators circuits.	Understand
CO 5	Interpret the transistor configurations for optimization of the operating point.	Apply
CO 6	Illustrate the amplifier circuits using transistors for computing hybrid parameters.	Apply

18. Topic Learning Outcome (TLOs):

SNo	**TOPIC(S)**	**TLO No**	**Topic Learning Outcome's**	**Course Outcome:**	Blooms Level
1	Electrical Circuits	TLO 1	Introduction to electrical circuits	CO1	Understand
		TLO 2	Basic Definitions of Electrical Circuits	CO 1	Understand
		TLO 3	Equivalent resistance of electrical circuits and source transformation of electrical circuits.	CO 1	Understand
2	Electrical laws	TLO 4	Basic Electric laws	CO 1	Understand
		TLO 5	Star to delta and delta bto star transformation	CO 1	Understand
3	Electrical analysis	TLO 6	Calculate voltages and currents with mesh analysis.	CO 1	Apply
		TLO 7	Calculate voltages and currents with nodal analysis	CO 1	Apply
4	AC Circuits	TLO 8	Demonstrate the basics of single-phase AC circuits	CO 1	Understand
5	Electrical Theorem	TLO9	Procedure for Superposition theorem	CO2	Understand
6	Electrical Theorem	TLO10	Procedure for Reciprocity theorem	CO2	Understand
7	Electrical Theorem	TLO11	Procedure for Thevenin's theorem	CO2	Understand
8	Electrical Theorem	TLO12	Procedure for Norton's theorem	CO2	Understand

SNo	**TOPIC(S)**	**TLO No**	**Topic Learning Outcome's**	**Course Out-come:**	Blooms Level
9	Electrical Theorem	TLO13	Procedure for Maximum Power Transfer theorem	CO2	Understand
10	3 phase voltages	TLO14	Voltage and current relationships in star and delta connections	CO2	Understand
11	DC Circuits	TLO 15	Apply the basic theorems to solve the problems on DC circuits.	CO2	Apply
12	3Phase cirrcuits	TLO 16	Basics of three-phase AC circuits	CO2	Understand
'13	DCmachines and AC machines	TLO 17	Illustrate the construction and operation of DC and AC motors and generators	CO3	Understand
14	DC machines	TLO 18	EMF equation of DC motors and generators	CO3	Understand
15	DC machines	TLO 19	Types of DC motors and generators	CO3	Understand
16	DC machines	TLO 20	Applications and losses of DC motors and generators	CO3	Understand
17	DC machines	TLO 21	Problems based on losses and Efficiency of DC motors and generators	CO3	Apply
18	semiconductor diode	TLO 22	Understand the basics of semiconductor elements	CO4	Understand
19	semiconductor diode characterictics	TLO 23	Illustrate the characteristics of the PN junction diode	CO4	Understand
20	rectifiers	TLO 24	Develop the rectifiers using diodes and their characteristics	CO4	Apply
21	Operation of semiconductor diode	TLO25	Operation of a diode as a switch	CO4	Understand
22	Zener diode	TLO26	Operation of Zener diode as the voltage regulator	CO4	Understand
23	Rectifier parameters	TLO27	Calculation of Rectifier parameters	CO4	Apply
24	Transistors	TLO28	Introduction to bipolar junction transistors	CO5	Understand
25	Transistor configurations	TLO29	Illustrate the characteristics of bipolar junction transistors with various configurations	CO5	Understand
26	Transistor principle	TLO30	Working principle of NPN Transistor	CO5	Understand
27	Transistor principle	TLO31	Working principle of PNP Transistor	CO5	Understand

SNo	TOPIC(S)	TLO No	Topic Learning Outcome's	Course Out-come:	Blooms Level
28	Transistor configuration	TLO32	Transistor characteristics under CE configuration	CO5	Understand
29	transistor configuration	TLO33	Transistor characteristics under CB configuration	CO5	Understand
30	transistor configuration	TLO34	Transistor characteristics under CC configuration	CO5	Understand
31	BJT characteristics	TLO35	Input and output characteristics of bipolar junction transistor	CO5	Understand
32	Amplifiers	TLO36	Understand the operation of a transistor as an amplifier	CO6	Understand
33	Amplifier circuits	TLO37	Understand the two port devices and networks of Amplifier circuits	CO6	Understand
34	Models of transistors	TLO38	Small signal operation and models for transistors	CO6	Understand
35	CE Amplifier	TLO39	Method of amplification in CE amplifier	CO6	Understand
36	H parameters	TLO40	Describe the h parameters of bipolar junction transistors with the concept of small signal operation	CO6	Understand

18. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
Project based skills Elements of electrical and electronics engineering for students based on qualitative and quantitative analysis of experimental skills

19. Content Delivery / Instructional Methologies:

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

20. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Table 4: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

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 12 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.

21. Course Content-Number of Modules: Five

MODULE I	**INTRODUCTION TO ELECTRICAL CIRCUITS . | Number of Lectures: 09**
	Concept: Ohm's law, Kirchhoff's laws, the equivalent resistance of networks, star to delta transformation, mesh and nodal analysis (with DC source only). Single phase AC circuits: representation of alternating quantities, RMS, average, form and peak factor, RLC series circuit. .
MODULE II	**NETWORK THEOREMS AND THREE PHASE VOLTAGES . | Number of Lectures: 10**
	Network Theorems: Superposition, reciprocity, Thevenin's, Norton's, Maximum power transfer theorems for DC excitation circuits. Three phase voltages (Definitions only): voltage and current relationships in star and delta connections. ;
MODULE III	**ELECTRICAL MACHINES AND SEMICONDUCTOR DIODES . |Number of Lectures: 10**
	DC and AC machines: Motors and generators, Principle of operation, parts, EMF equation, types, applications, losses and efficiency. **Semiconductor diode:** P-N Junction diode, symbol, V-I characteristics, half wave rectifier, full wave rectifier, bridge rectifier and filters, diode as a switch, zener diode as a voltage regulator..
MODULE IV	**BIPOLAR JUNCTION TRANSISTOR AND APPLICATIONS . | Number of Lectures: 10**
	Bipolar junction transistor: characteristics and configurations, working principle NPN and PNP transistor, CE, CB, CC configurations – input and output characteristics, transistor as a switch..

MODULE V	**TRANSISTOR AMPLIFIERS** . | **Number of Lectures: 09**
	Amplifier circuits: Two port devices and network. - Small signal models for transistors – concept of small signal operation - amplification in CE amplifier - h parameter model of a BJT- CE, CB and Emitter follower analysis..

TEXTBOOKS

1. M.S.Sukhija,T K Nagsarkar, " *Basic Electrical and Electronics Engineering* ." Oxford, 1st Edition, 2012.
2. Salivahanan, " *Electronics devices and Circuits* ." TMH, 4th Edition, 2012.

REFERENCE BOOKS:

1. C.L. Wadhwa & "*Electrical Circuit Analysis including Passive Network Synthesis*", International,2nd edition,2009.
2. DavidA Bell, "*Electric circuits*", Oxford University Press,7th edition,2009.
3. P.S Bimbra "*Electrical Machines*", KhannaPublishers,2nd edition,2008.
4. D.P. Kothari and I. J. Nagrath, " *Basic Electrical Engineering*", Tata McGraw Hill, 4th Edition, 2021.

MATERIALS ONLINE:

1. https://www.kuet.ac.bd/webportal/ppmv2/uploads/1364120248DC%20Machines
2. https://www.eleccompengineering.files.wordpress.com/2014/08/a-textbook-of-electrical-technologyvolume-ii-ac-and-dc-machines-b-l-thferaja.pdf
3. https://www.geosci.uchicago.edu/ moyer/GEOS24705/Readings/Klempner_Ch1.pdf
4. https://www.ibiblio.org/kuphaldt/electricCircuits/DC/DC.pdf
5. https://www.users.ece.cmu.edu/ dwg/personal/sample.pdf.
6. https://www.iare.ac.in

22. COURSE PLAN:

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

S.No	Topics to be covered	Course Out-come's	Reference
	Discussion on OBE		
1	Discussion on Outcome Based Education, CO, POs and PSOs		

S.No	Topics to be covered	Course Out-come's	Reference
CONTENT DELIVERY (THEORY)			
1	Introduction to electrical circuits	CO 1	T1:1.1-1.3
2	Basic definitions of electrical circuits	CO 1	T1:1.4-1.8
3	Equivalent resistance of electrical circuits and Source transformation of electrical circuits	CO 1	T1:2.6
4	Star to delta and delta to star transformation	CO 1	T1:2.7
5	Mesh analysis and problems on mesh analysis	CO 1	T1:2.9
6	Nodal Analysis and problems on nodal analysis	CO 1	T1:2.8
7	Representation of alternating quantities average value, rms value, form factor and peak factor for various waveforms	CO 1	T1:4.1-4.5
8	Concept of impedance, admittance and complex power	CO 1	T1:4.7-4.8
9	Procedure for superposition theorem and problems	CO 2	T1:2.11
10	Procedure for reciprocity theorem and problems	CO 2	T1:2.11.1
11	Procedure for Thevinin's theorem and problems	CO 2	T1:2.11.2
12	Problems on Thevinin's theorem	CO 2	T1:2.11.3
13	Procedure for Norton's theorem and problems	CO 2	T1:2.11.4
14	Problems on Norton's theorem	CO 2	T1:2.11.5
15	Procedure for Maximum power transfer theorem and problems	CO 2	T1:2.11.6
16	Voltage and current relationships in star delta connections	CO 2	T1: 5.2
17	Construction and operation of DC machines	CO 3	T1: 9.2
18	Classification of DC generators and efficiency	CO 3	T1: 9.6
19	Types of DC motors, losses and efficiency	CO 3	T1: 9.7
20	Introduction to semiconductor devices	CO 4	T2: 1.1
21	PN junction diode, symbol and its voltage current characteristics	CO 4	T2: 1.2
22	Operation of half wave rectifier with and without filters	CO 4	T2: 1.9
23	Operation of full wave rectifier with and without filters	CO 4	T2: 1.10
24	Operation of diode as switch	CO 4	T2: 1.11
25	Operation of zener diode as voltage regulator	CO 4	T2: 1.12
26	Calculation of Rectifier parameters	CO 4	T2: 1.10
27	Introduction to bipolar junction transistors	CO 5	T2: 3.1
28	Working principle of NPN transistor	CO 5	T2: 3.1.2
29	Operation of PNP transistor	CO 5	T2: 3.1.3
30	Transistor characteristics under CB configuration	CO 5	T2: 3.6
31	Transistor characteristics under CE configuration	CO 5	T2: 3.7
32	Transistor characteristics under CC configuration	CO 5	T2: 3.8
33	Biasing and load line of transistors	CO 5	T2: 4.1
34	Operation of transistor as an amplifier	CO 6	T2: 3.9
35	Introduction to port devices and network	CO 6	T2: 5.2

S.No	Topics to be covered	Course Out-come's	Reference
36	Concept of small signal operation for transistors	CO 6	T2: 5.2.7
37	Amplification in common emitter amplifier	CO 6	T2: 5.3.1
38	Calculation of h parameter model of a BJT CE configuration	CO 6	T2: 5.3.2
39	Calculation of h parameter model of a BJT CB configuration	CO 6	T2: 5.3.3
40	Calculation of h parameter model of a BJT CC configuration.	CO 6	T2: 5.5
PROBLEM SOLVING/ CASE STUDIES			
1	Problems on equivalent resistance	CO 1	T1: 2.6
2	Problems on star to delta and delta to star transformation	CO 1	T1: 2.7
3	Problems on mesh and nodal analysis	CO 1	T1: 2.8-2.9
4	Problems on superposition theorem	CO 2	T1: 2.11
5	Problems on reciprocity theorem	CO 2	T1: 2.11.1
6	Problems on Maximum power transfer theorem	CO 2	T1: 2.11.2
7	Problems on emf equation of DC generators	CO 3	T1: 9.2
8	Problems on efficiency of DC generators	CO 3	T1: 9.3
9	Problems on DC motors	CO 3	T1: 9.4
10	Problems on efficiency of DC motors	CO 3	T1: 9.5
11	Problems on alternator emf equation	CO 4	T1: 7.4
12	Problems on alternators	CO 4	T1: 7.5
13	Problems on rectifiers using diodes	CO 4	T2: 1.10
14	Problems on transistors CB configuration	CO 5	T2: 3.6
15	Problems on transistors CE and CC configuration	CO 6	T2: 3.7-3.8
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Introduction to Engineering Mechanics	CO 1	T1: 1.1-1.12
2	Definition and terminology from network theorems and three phase AC circuits	CO 2	T1: 2.1-2.12
3	Definition and terminology from electrical machines and diodes	CO 3, CO 4	T1: 7,8,9 T2: 1.1-1.12
4	Definition and terminology from transistors	CO 5	T2: 3.1-3.10
5	Definition and terminology from transistor amplifier circuits	CO 6	T2: 9.1-9.6
DISCUSSION OF TUTORIAL QUESTION BANK			
1	Question bank from electrical circuits	CO 1	T1: 1.1-1.12
2	Question bank from network theorems and three phase AC circuits	CO 2	T1: 1.1-1.12
3	Question bank from electrical machines and diodes	CO 3,CO 4	T1: 7,8,9 T2: 1.1-1.12
4	Question bank from electrical machines and diodes	CO 5	T2: 3.1-3.10
5	Question bank from transistor amplifier circuits	CO 6	T2:9.1-9.6

23. PROGRAM OUTCOMES & PROGRAM SPECIFIC 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
Program Specific Outcomes	
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..

Program Outcomes	
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.

24. HOW PROGRAM OUTCOMES ARE ASSESSED:

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

25. 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	CIE/SEE/AAT

3 = High; 2 = Medium; 1 = Low

26. 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	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-

27. 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 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
	PSO 1	Design and Supervise Sub-Structures and Super Structures for Residential and Public Buildings, Industrial Structures, Irrigation Structures, Power Houses, Highways, Railways, Airways, Docs and Harbours.	1
CO 2	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.	4
	PSO 1	Design and Supervise Sub-Structures and Super Structures for Residential and Public Buildings, Industrial Structures, Irrigation Structures, Power Houses, Highways, Railways, Airways, Docs and Harbours.	1
CO 3	PO 1	The principle of operation and characteristics of DC and AC machines are explained by applying engineering fundamentals including device physics.	3
	PO 2	Calculate the voltage generated and torque developed in DC and AC generators and motors by using first principles of mathematics .	4
CO 4	PO1	Illustrate the volt-ampere characteristics of semiconductor devices to derive mathematical model for diode current, static and dynamic resistance by applying the principles of mathematics and scientific principles for solving complex engineering problems.	2
	PO 2	Understand the given problem statement and formulate the static and dynamic resistance from the volt-ampere characteristics of the semiconductor devices using experimental design.	3
CO 5	PO 1	Understand the characteristics and operation of transistors with the knowledge of engineering fundamentals	2
CO 6	PO 1	Understand the mathematical principles for design the biasing techniques for BJT amplifier circuits for stable operation by applying the methodology	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 2	Demonstrate the calculation of h parameters with small signal operation using the principles of mathematics and natural sciences.	4

28. 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	4	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 2	3	4	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 3	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-

29. 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	40	-	-	-	-	-	-	-	-	-	-	33.33	-	-
CO 2	100	40	-	-	-	-	-	-	-	-	-	-	33.33	-	-
CO 3	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.6	30	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.6	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.6	40	-	-	-	-	-	-	-	-	-	-	-	-	-

30. 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≤ 40% – Low/ Slight

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

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

31. ASSESSMENT METHODOLOGY DIRECT:

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

32. ASSESSMENT METHODOLOGY INDIRECT:

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

33. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1		
2		
3		
4		This subject improves the quality of education in engineers and gives the awareness of electrical usage in day to day life.
5		
6		
7		

8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	Responsible Consumption and Production: This subject gives the importance of electricity, by learning how to optimize electrical energy for different applications, students can contribute to reducing energy consumption and minimizing electronic waste and the need for saving energy.
13	CLIMATE ACTION	
14	LIFE BELOW WATER	

15	LIFE ON LAND	
16	PEACE, JUSTICE AND STRONG INSTITUTIONS	
17	PARTNERSHIPS FOR THE GOALS	

Approved by: Board of Studies in the meeting conducted on - 24/08/2023

Signature of Course Coordinator **HOD**
Mr.G.Viswanath, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

OBJECT ORIENTED PROGRAMMING
COURSE TEMPLATE

1	Department	MECHANICAL ENGINEERING				
2	Course code	ACSD01				
3	Course Title	OBJECT ORIENTED PROGRAMMING				
4	Class / Semester	I / I				
5	Regulation	BT-23				
6	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	0	3	-	-
7	Type of course (Tick type of course)	Core	Professional Elective	Open Elective	VAC	MOOCs
		✓	-	-	-	-
8	Course Offered	Odd Semester ✓		Even Semester ×		
9	Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)					
	Lectures: 48 hours		Tutorials: 0 hours		Practical: – hours	
10	Course Coordinator	Mr. D. Atchuta Ramacharyulu				
11	Date Approved by BOS	28/08/2023				
12	Course Webpage	https://www.iare.ac.in/?q=pages/btech-course-syllabi-bt23-cse				
13	Course Prerequistes	Level	Course Code	Semester	Prerequisites	
		-	-	-	-	

14. Course Overview

The course provides a solid foundation in object-oriented programming concepts in using them. It includes concepts object-oriented concepts such as information hiding, encapsulation, and polymorphism. It contrasts the use of inheritance and composition as techniques for software reuse. It provides an understanding of object-oriented design using graphical design notations such as Unified Modelling Language (UML) as well as object design patterns.

15. Course Objectives:

The students will try to learn:

I	The fundamental concepts and principles of object-oriented programming in high-level programming languages.
II	Advanced concepts for developing well-structured and efficient programs that involve complex data structures, numerical computations, or domain-specific operations.
III	The design and implementation of features such as inheritance, polymorphism, and encapsulation for tackling complex problems and creating well-organized, modular, and maintainable code.
IV	The usage of input/output interfaces to transmit and receive data to solve real-time computing problems.

16. Course Outcomes:

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

CO 1	**Interpret** the features of object-oriented programming languages, comparison, and evolution of programming languages.
CO 2	**Model** the real-world scenario using class diagrams and exhibit communication between objects.
CO 3	**Estimate** the need for special functions for data initialization.
CO 4	**Outline** the features of object-oriented programming for binding the attributes and behavior of a real-world entity.
CO 5	**Use** the concepts of streams and files that enable data management to enhance programming skills.
CO 6	**Develop** contemporary solutions to software design problems using object-oriented principles.

17. Topic Learning Outcome (TLOs):

S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
1	Objects and legacy systems	1	**Summarize** fundamental concepts of programming through a procedural approach.	CO 1	Understand
		2	**Differentiate** between OOP and other programming paradigms such as procedural programming.	CO 1	Understand
2	Object-oriented programming	3	**Gain knowledge** to design and implement software solutions using OOP principles.	CO 1	Remember

S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
		4	**Discuss** applications of OOP in software development, graphical user interface development, and mobile application development.	CO 1	Understand
3	Abstraction: Levels of abstraction	5	**Identify** the data components and behaviors of multiple abstract data types.	CO 1	Remember
		6	**Apply** techniques of decomposition to break a program into smaller pieces.	CO 1	Apply
		7	**Implement** a coherent abstract data type with loose coupling between components and behaviors.	CO 6	Apply
4	Classes and objects: Fields, methods, messages	8	**Interpret** knowledge by defining classes and creating instances to represent and interact with real-world entities or concepts.	CO 2	Understand
		9	**Instantiate** objects from classes to understand the relationship between classes and objects.	CO 2	Remember
5	Access specifiers: public, private, protected	10	**Enumerate** access specifiers' visibility and accessibility of class members (variables and methods) within different parts of a program.	CO 2	Remember
6	Class diagrams	11	**Create and interpret** class diagrams to visually represent classes, relationships, and interactions.	CO 2	Apply
7	Encapsulation	12	**Review** the encapsulation principle by specifying who can access and modify class members.	CO 3	Remember
		13	**Implement** encapsulation by using access modifiers (public, private, protected) to control access to class members.	CO 2	Apply
		14	**Use** static fields to keep a count of the number of objects that have been instantiated or to store a value that must be shared among all instances.	CO 6	Apply

S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
8	Special member functions: Constructors, destructors	15	**Select** the constructor methods in initializing object attributes when instances are created.	CO 3	Remember
		16	**Illustrate** destructors to manage resources and perform cleanup operations in the classes such as closing files, releasing locks, or cleaning up cached data.	CO 6	Apply
9	Overloading: Functions, operators, constructors	17	**Express** the behavior of operators of a class that enriches programming skills in various ways that are both intuitive and flexible.	CO 3	Understand
		18	**Infer** that data is in a compatible format for specific operations or assignments to avoid unexpected behavior or data loss.	CO 3	Understand
		19	**List** the types of inheritance to facilitate code reuse, organization, and hierarchy for modeling complex systems.	CO 4	Remember
10	Inheritance: Subclasses, and method overriding	20	**Use** subclassing to design class hierarchies that allow code to be reused for distinct subclasses.	CO 4	Apply
		21	**Identify** the type of inheritance to create specialized classes that inherit the properties and behaviors of more general classes.	CO 4	Remember
11	Virtual functions	22	**Demonstrate** code flexibility using virtual functions to work with different types of objects through a common interface.	CO 4	Understand
12	Polymorphism	23	**Review** polymorphism on different derived classes to be treated as objects of their common base class.	CO 4	Remember
		24	**Understand and demonstrate** polymorphic behavior through function overriding and function overloading.	CO 4	Understand

S No	Topic(s)	TLO No	Topic Learning Outcome	Course Out-come	Blooms Level
13	Streams and files	25	**Illustrate** console input and output to create applications that interact with users, and process data.	CO 5	Understand
		26	**Label** objects to store them in files and deserialize them to recreate objects from files.	CO 5	Remember
		27	**Demonstrate** file-handling operations to enrich programming capabilities to create more sophisticated applications that interact with and manipulate external data sources effectively.	CO 5	Understand
		28	**Use** output with manipulators and predefined manipulatorsfor formatting input and output data.	CO 6	Apply
14	Command line arguments	29	**Interpret** software systems and applications to configure and control via command-line arguments.	CO 5	Understand

18. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
1. Programming skills - The tech industry evolves rapidly, and staying up-to-date with the latest programming languages, frameworks, and development practices is crucial. Combining OOP skills with a commitment to continuous learning demonstrates a student's dedication to staying relevant in a dynamic field.
2. Project-based skills - Creating projects that utilize OOP principles allows a student to apply theoretical knowledge to real-world scenarios. This hands-on experience helps solidify their understanding of how OOP concepts work in practice.

19. Content Delivery / Instructional Methologies:

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

20. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for each Definitions and Terminology / Quiz, and the remaining 10 marks for Tech Talk / Assignments.

Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE:

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Semester End Examination (SEE): The SEE is conducted for 60 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. No choice is given in the first two modules. Each question carries 12 marks. There could be a maximum of two sub-divisions in a question.

21. Course content - Number of modules: Five

MODULE I	**Object-oriented concepts**	**Number of Lectures: 09**
	Objects and legacy systems, procedural versus Object-oriented programming, top-down and bottom-up approaches and their differences, benefits of OOP, applications of OOP, and features of OOP. **Abstraction:** Layers of abstraction, forms of abstraction, abstraction mechanisms.	
MODULE II	**Classes and objects**	**Number of Lectures: 09**
	Classes and objects: Object data, object behaviors, creating objects, attributes, methods, messages, creating class diagrams. **Access specifiers and initialization of class members:** Accessing members and methods, access specifiers - public, private, protected, memory allocation. Static members, static methods.	
MODULE III	**Special member functions and overloading**	**Number of Lectures: 09**
	Constructors and destructors: Need for constructors and destructors, copy constructors, dynamic constructors, parameterized constructors, destructors, constructors and destructors with static members. **Overloading:** Function overloading, constructor overloading, operator overloading - rules for overloading operators, overloading unary and binary operators, friend functions.	

MODULE IV	**Inheritance and polymorphism** | **Number of Lectures: 09**
	Inheritance: types of inheritance, base class, derived class, usage of final, ambiguity in multiple and multipath inheritances, virtual base class, overriding member functions, order of execution of constructors and destructors. **Polymorphism and virtual functions:** Virtual functions, pure virtual functions, abstract classes, introduction to polymorphism, static polymorphism, dynamic polymorphism.
MODULE V	**Console I/O and working with files** | **Number of Lectures: 09**
	Console I/O: Concept of streams, hierarchy of console stream classes, unformatted I/O operations, managing output with manipulators. **Working with files:** Opening, reading, writing, appending, processing, and closing different types of files, and command line arguments.

TEXTBOOKS

1. Matt Weisfeld, *The Object-Oriented Thought Process*, Addison Wesley Object Technology Series, 4th Edition, 2013.

REFERENCE BOOKS:

1. Timothy Budd, *Introduction to object-oriented programming*, Addison Wesley Object Technology Series, 3rd Edition, 2002.
2. Gaston C. Hillar, *Learning Object-Oriented Programming*, Packt Publishing, 2015.
3. Kingsley Sage *Concise Guide to Object-Oriented Programming*, Springer International Publishing, 1st Edition, 2019.
4. Rudolf Pecinovsky, *OOP - Learn Object Oriented Thinking and Programming*, Tomas Bruckner, 2013.
5. Grady Booch, *Object-oriented analysis and design with applications*, Addison Wesley Object Technology Series, 3rd Edition, 2007.

MATERIALS ONLINE:

1. https://docs.oracle.com/javase/tutorial/java/concepts/
2. https://www.w3schools.com/cpp/
3. https://www.edx.org/learn/object-oriented-programming
4. https://www.geeksforgeeks.org/introduction-of-object-oriented-programming/

22. 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			
Discussion on Outcome Based Education, CO, POs, and PSOs			
CONTENT DELIVERY (THEORY)			
1	Objects and legacy systems	CO 1	T1, Pg: 05
2	Object-oriented programming	CO 1	T1, Pg: 06
3	Procedural versus object-oriented programming	CO 1	T1, Pg: 07, R4: Pg: 13
4	Top-down and bottom-up approaches and their differences	CO 1	R5: 1.5
5	Benefits and applications of OOP	CO 1	R5: 1.6
6	Features of OOP	CO 1	T1, Pg: 12
7	Abstraction and layers of abstraction	CO 1	R1: 2.1
8	Forms of abstraction	CO 1	R1: 2.2
9	Abstraction mechanisms	CO 1	R1: 2.3
10	Object data, object behaviors, creating objects	CO 2	T1, Pg:12, 13
11	Attributes, methods, messages	CO 2	T1, Pg:19, 20
12	Classes	CO 2	T1, Pg: 17
13	Creating class diagrams with examples	CO 2	T1, Pg: 20
14	Accessing members	CO 2	R5: 3.1
15	Accessing methods	CO 2	R5: 3.2
16	Access specifiers - public, private, protected with examples	CO 2	T1, Pg: 188
17	Memory allocation	CO 2	T1, Pg: 90
18	Static members, static methods	CO 2	T1, Pg: 90
19	Constructors need constructors and destructors	CO 3	T1, Pg: 71
20	Copy constructors with examples	CO 3	R1: 15.1
21	Dynamic constructors with examples	CO 3	R1: 15.3
22	Parameterized constructors and destructors	CO 3	R1: 15.3.1
23	Constructors and destructors with static members	CO 3	R1: 15.3.2
24	Function overloading, constructor overloading	CO 3	R1: 15.3.2
25	Operator overloading - rules for overloading operators	CO 3	R1: 15.3.2
26	Overloading unary and binary operators	CO 3	R1: 15.3.2
27	Friend functions	CO 3	R1: 15.3.2
28	Inheritance and types of inheritance	CO 4	T1, Pg: 153
29	Base class, derived class, usage of final	CO 4	T1, Pg: 45
30	Ambiguity in multiple and multipath inheritance	CO 45	T1, Pg: 136

S.No	Topics to be covered	CO's	Reference
31	Virtual base class, overriding member functions	CO 4	T1, Pg: 137
32	Order of execution of constructors and destructors	CO 4	T1, Pg: 28 R1: 14.1
33	Virtual functions, pure virtual functions	CO 4	T1, Pg: 28
34	Abstract classes	CO 4	T1, Pg: 21
35	Introduction to polymorphism	CO 4	T1, Pg: 21
36	Static polymorphism, dynamic polymorphism.	CO 4	T1, Pg: 21
37	Concept of streams, hierarchy of console stream classes.	CO 5	T1, Pg: 225
38	Unformatted I/O operations	CO 5	T1, Pg: 221
39	Managing output with manipulators and predefined manipulators.	CO 5	T1, Pg: 225
40	Data streams, the opening of a file	CO 5	R1: 2.5
41	Reading/writing a character from/into a file	CO 5	T1, Pg: 225
42	Appending into a file	CO 5	T1, Pg: 232
43	Processing and closing files	CO 6	T1, Pg: 227
44	Different types of files and file systems.	CO 5	T1, Pg: 226
45	Command line arguments	CO 5	T1, Pg: 228
46	Question bank discussion	CO 6	T1
47	Question bank discussion	CO 6	T1
48	Question bank discussion	CO 6	T1
PROBLEM SOLVING/ CASE STUDIES			
1	Design a class to represent books with attributes like title, author, and ISBN. Create a class for library patrons with borrowing history and due dates. Implement methods to borrow and return books, tracking availability, and due dates.	CO 1	
2	Design a class for products with properties like name, price, and description. Develop a shopping cart class that allows users to add and remove products. Use objects to create an interactive shopping experience with calculated totals.	CO 1	
3	Create a class for students with attributes like name, age, and enrolment status. Design a class for courses with properties like title, instructor, and schedule. Implement methods to enroll students in courses and track their progress.	CO 1	
4	Design a class representing a geometric shape (e.g., circle, rectangle). Use the const keyword to declare methods that provide information about the shape without modifying its properties.	CO 2	

S.No	Topics to be covered	CO's	Reference
5	Design a university class with nested classes for departments and courses. Utilize nested classes to represent the hierarchical structure of the university's organization.	CO 2	
6	Design a class representing employees with attributes like name, employee ID, and position. Use a constructor to initialize employee information when an object is created. Implement a destructor to handle any cleanup tasks or logging when an employee object is destroyed.	CO 2	
7	Implement a class for complex numbers with overloaded operators for addition, subtraction, multiplication, and division. Allow users to perform arithmetic operations on complex numbers using intuitive syntax.	CO 3	
8	Design a class for representing dates and overload comparison operators. Allow users to compare dates and determine their chronological order.	CO 3	
9	Create a utility to convert measurements between different units (e.g., inches to centimeters, pounds to kilograms). Utilize type conversion to handle unit conversions based on user input.	CO 3	
10	Design a base class Character with virtual functions for movement, attack, and interaction. Implement derived classes PlayerCharacter and EnemyCharacter that override the virtual functions. Use polymorphism to handle interactions between various characters in the game.	CO 4	
11	Create a base class Employee with virtual functions for calculating salary and displaying information. Implement derived classes RegularEmployee and ContractEmployee that override the virtual functions.	CO 4	
12	Design classes representing accounts (e.g., savings, checking) and customers. Use encapsulation to hide sensitive data and provide methods to deposit, withdraw, and check balances. Apply inheritance to create specialized account types, such as VIP accounts with additional features.	CO 4	
13	Develop an application to manage tasks and to-do lists. Use console stream classes to display tasks, prompt users for new tasks, and mark tasks as completed. Enable users to save and load their to-do lists to/from text files using file stream classes.	CO 5	
14	Create a calculator application that performs basic arithmetic operations. Utilize console stream classes to prompt users for operands and operators, and display the calculation results.	CO 5	

S.No	Topics to be covered	CO's	Reference
15	Create a utility that parses and analyzes log files. Read log files, extract relevant information, and present summaries. Use file streams to process large log files efficiently.	CO 5	
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Introduction to programming and object legacy.	CO 1	
2	Constructor and destructor.	CO 2	
3	Operator overloading.	CO 3	
4	Data hiding.	CO 4	
5	Command line arguments.	CO 5	
DISCUSSION OF TUTORIAL QUESTION BANK			
1	Classes and objects.	CO 1	
2	Constructors and destructors.	CO 2	
3	Overloading a unary and binary operator using friend function and member function.	CO 3	
4	Ambiguity in derived classes for multipath inheritance.	CO 4	
5	Console stream classes.	CO 5	

23. Program outcomes and Program specific 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
Program Specific Outcomes	
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.

24. 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:** Identity, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using the 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 public health and safety, and 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 modeling 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.	2	Tech talk/Definitions and terminology
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	CIE/SEE

25. 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	Tech talk /Definitions and terminology/ Assignments

3 = High; 2 = Medium; 1 = Low

26. 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	✓	✓	✓	-	✓	-	-	-	-	✓	-	✓	-	-	-

27. Justifications for CO – PO / PSO mapping - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Understand (knowledge) the basic concept of object-oriented programming while evaluating mathematical expressions in program statements. These concepts provide insight into expression evaluation by applying the principles of mathematics and science.	3
	PO 5	With the help of modern engineering tools, we can easily understand the basic concept of objects and classes while evaluating mathematical expressions in program statements.	1
	PO 10	Extend the knowledge of object-oriented programming to communicate effectively with the engineering community.	1
	PSO 3	Acquire sufficient knowledge of object-oriented concepts and apply it in real-time to build a successful career and do higher studies.	2
CO 2	PO 1	By applying the knowledge of mathematics, science, and engineering fundamentals we can effectively use the properties of OOP.	3
	PO 2	Apply nested classes in problem identification, statement, and validation.	5
	PO 3	Apply constructors and destructors to investigate and understand different complex engineering problems efficiently.	8
	PO 5	Apply static members to model complex engineering activities.	1
	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.	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.	8
	PO 3	Demonstrate the importance of indexing mechanisms in sequences while developing solutions for complex engineering problems and design systems using principles of mathematics, science, and engineering fundamentals. Use creativity to develop more innovative solutions.	6
	PO 5	Demonstrate overloading operators with the usage of modern tools.	1

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PSO 3	Infer sufficient knowledge of container data types and apply it in real-time for building a successful career and doing higher studies.	2
CO 4	PO 1	Demonstrate different modules/packages in object-oriented programming while developing solutions using the fundamentals of mathematics, science, and engineering.	3
	PO 3	Understand the usage of modules/packages while developing solutions for complex engineering problems and design systems using principles of mathematics, science, and engineering fundamentals. Use creativity to develop more innovative solutions.	8
	PO 5	Interpret different string functions by using modern tools.	1
	PO 10	Extend the focus to understanding the usage of modules/packages and communicating effectively with the engineering community.	2
	PO 12	Summarize string handling functions that involve manipulating and managing text or character data for tasks like data validation, formatting, and communication.	7
CO 5	PO 1	Make use of parameter passing and different types of arguments in user-defined functions to design efficient modular programs by applying the knowledge of mathematics, science, and Engineering fundamentals.	3
	PO 2	Apply modular programming concepts for problem identification, formulation, and data collection.	8
	PO 3	Select a strong foundation for writing efficient modular programs using parameter-passing mechanisms for career building by understanding the requirements and communicating effectively with the engineering community.	7
	PO 5	Develop different functions by using modern tools.	1
CO 6	PO 1	Apply scientific principles and methodologies, mathematical principles, and other engineering disciplines for procedural and object-oriented programming.	3
	PO 2	Apply object-oriented concepts in problem identification, statement, and validation.	7
	PO 3	Identify the need for object-oriented concepts while developing solutions for complex engineering problems and design systems using principles of mathematics, science, and engineering fundamentals. Use creativity to develop more innovative solutions.	7
	PO 5	Develop object-oriented principles using modern tools.	1
	PO 10	Apply the knowledge of object-oriented programming to communicate effectively with the engineering community.	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 12	Identify the need for object-oriented principles for the preparation and the ability to engage in independent and lifelong learning	6

28. Total count of key competencies for CO – PO / PSO mapping:

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

29. Percentage of key competencies CO – PO / PSO:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	0.0	0.0	0.0	100	0.0	0.0	0.0	0.0	20	0.0	0.0	0.0	0.0	100
CO 2	100	50	80	0.0	100	0.0	0.0	0.0	0.0	60	0.0	0.0	0.0	0.0	0.0
CO 3	100	0.0	60	0.0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100
CO 4	100	0.0	80	0.0	100	0.0	0.0	0.0	0.0	40	0.0	88	0.0	0.0	0.0
CO 5	100	80	70	0.0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 6	100	80	70	0.0	100	0.0	0.0	0.0	0.0	40	0.0	75	0.0	0.0	0.0

30. Course articulation matrix PO / PSO mapping:

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

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

2 - 40 % $< C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	3	-	-	-	-	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 2	3	2	3	-	3	-	-	-	-	3	-	-	-	-	-
CO 3	3	-	3	-	3	-	-	-	-	-	-	-	-	-	3
CO 4	3	-	3	-	3	-	-	-	-	2	-	3	-	-	-
CO 5	3	2	3	-	3	-	-	-	-	-	-	-	-	-	-
CO 6	3	3	3	-	3	-	-	-	-	2	-	3	-	-	-
TOTAL	-	7	15	-	-	-	-	-	-	8	-	6	-	-	6
AVERAGE	3	2.3	3	-	3.0		-	-	-	2.0	-	3.0	-	-	3.0

31. Assessment methodology - Direct:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Definitions and Terminology	✓	Tech talk / 5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓	Quiz	✓	Tech Talk	✓

32. Assessment methodology - Indirect:

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

33. Relevance to Sustainability goals

Write a brief description of the course and its relevance to SDGs.

1		
2		

3	GOOD HEALTH AND WELL-BEING	
4	QUALITY EDUCATION	**Quality education:** Guarantee an education system that is both inclusive and fair, offering high-quality learning experiences and lifelong opportunities accessible to all.
5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	
7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Industry, innovation, and infrastructure:** Strong OOP skills enable to design and development of services like microservice architecture, cloud computing, machine learning, and AI integration in a modular and maintainable way, contributing to a more flexible and scalable infrastructure.

10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	**Sustainable cities and communities:** OOP skills can develop software solutions that contribute to urban sustainability, improve quality of life, and address challenges like smart city solutions, energy efficiency and monitoring, waste management systems, public transportation optimization, environmental sensor networks, education, and awareness faced by modern cities.
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	
13	CLIMATE ACTION	
14	LIFE BELOW WATER	
15	LIFE ON LAND	
16	PEACE, JUSTICE AND STRONG INSTITUTIONS	

17	PARTNERSHIPS FOR THE GOALS	

Approved by: Board of Studies in the meeting conducted on 28-08-2023.

Signature of Course Coordinator **HOD ME**
Mr. D.Atchuta Ramacharyulu, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**MECHANICAL ENGINEERING**			
2	Course Title	**PROFESSIONAL COMMUNICATION LABORATORY**			
3	Course Code	AHSD04			
4	Program	B.Tech			
5	Semester	I Semester			
6	Regulation	BT23			
7	Structure of the course	Practical			
		Lecture Hours		Practical Hours	
		3		3	
8	Course Offered	Odd Semester ✓		Even Semester ×	
9	Course Coordinator	Dr Jan Mohmad Pandit			
10	Date Approved by BOS	24/08/2023			
11	Course Webpage	https://www.iare.ac.in/?q=pages/btech-course-syllabi-bt23-ae			
12	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**
		B.Tech	AHSD04	I	-

13. Course Overview

This laboratory course is designed to introduce students to create a wide exposure on language learning techniques of the basic elements of listening skills, speaking skills, reading skills and writing skills. In this laboratory, students are trained in communicative English language skills, phonetics, word accent, word stress, rhythm, intonation, oral presentations and extempore speeches. Students are also taught in terms of seminars, group-discussions, presenting techniques of writing, participating in role plays, telephonic etiquettes, asking and giving directions, information transfer, debates, description of persons, places and objects etc. The laboratory encourages 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.

18. COURSE OBJECTIVES:

The students will try to learn:

I	English speech sounds, word accent, intonation and stress patterns for effective pronunciation.
II	Critical aspect of speaking and reading for interpreting in-depth meaning between the sentences.

III	Language techniques for social interactions such as public speaking, group discussions and interviews.
IV	Computer-assisted multi-media instructions and independent language learning.

19. COURSE OUTCOMES:

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

CO 1	**Articulate** the use of draw, modify and dimension commands of AutoCAD for development of 2D and 3D drawings.	Understand
CO 2	**Differentiate**stress shifts, syllabification and make use of past tense and plural markers effectively in connected speech; besides participate in role plays with confidence.	Understnad
CO 3	**Apply** weak forms and strong forms in spoken language and maintain intonation patterns as a native speaker to avoid mother tongue influence; moreover, practice various etiquettes at professional platform.	Understand
CO 4	**Demonstrate** Errors in pronunciation and the decorum of oral presentations; for that reason, take part joining in group discussions and debates with much critical observations	Understand
CO 5	**Strengthen** writing effective messages, notices, summaries and also able to write reviews very critically of art and academical videos.	Understnad
CO 6	**Argue** scholarly, giving the counters to open ended experiments, and also writing slogans for the products talentedly.	Understand

14. Employability Skills

1. **Employment advantage:**Effective English language and communication skills are crucial in many aspects of life, including education, business, workplace and social interactions. Proficient English language skills enable individuals to express themselves clearly, understand others, and engage in meaningful conversations. As the primary language of communication across the globe, proficiency in English is a highly sought-after skill in the international workplace and one of the benefits of learning English is therefore that it significantly boosts our job opportunities

16. Content Delivery / Instructional Methologies:

✓	Day to Day lab evaluation	✓	Demo Video	✓	Viva Voce questions	x	Open Ended Experiments
x	Competitions	x	hackathons	x	Certifications	x	Probing Further Questions

17. Evaluation Methodology:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

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.

Table 4: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
					20

Table 5: Programming based

Objective	Analysis	Design	Conclusion	Viva voce	Total
					20

Semester End Examination:

The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.

In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

20. SYLLABUS:

CO 1	**Recognise English speech sounds in order to execute formal and informal communication**
	1. Introduction to pronunciation 2. Introducing self and introducing others and feedback 3. Introduction to phonetics, listening to English sounds, Vowel and Consonant sounds 4. Describing a person or place or a thing using relevant adjectives – feedback 5. Pronunciation practice
CO 2	**Construct required dialogues in role plays in verbal communication**
	1. Role plays on fixed expressions in various situations 2. Structure of syllables 3. Asking for directions and giving directions 4. Weak forms and strong forms 5. Intonation
CO 3	**ADifferentiate mother tongue influence while speaking English in JAM sessions, debates, group discussions and telephonic conversations.**
	1. Word accent and stress shifts 2. JAM Sessions using public address system 3. Extempore-Picture 4. Etiquette 5. Debates 6. Listening comprehension 7. Group discussion
CO 4	**Pronounce past tense and plural markers and weak forms and strong forms as a native speaker.**
	1. Past tense and plural markers 2. Neutralization of Mother Tongue Influence (MTI) 3. Weak forms and strong forms 4. Common errors in pronunciation practice through tongue twisters 5. Minimal pairs

CO 5	**Demonstrate the techniques of writing leaflets, messages and notices..**
	1. Writing slogan related to the image 2. Providing reviews and remarks 3. Writing slogan related to the image 4. Demonstration on how to write leaflets, messages and notices
CO 6	**Use language appropriately during interviews and oral presentations.**
	1. Oral presentations 2. Techniques and methods to write summaries and reviews of videos 3. Information transfer 4. Open ended experiments-phonetics practice 5. Open ended experiments-text to speech

Note: One Course Outcome may be mapped to multiple number of experiments.

TEXTBOOKS

1. Professional Communication laboratory manual.

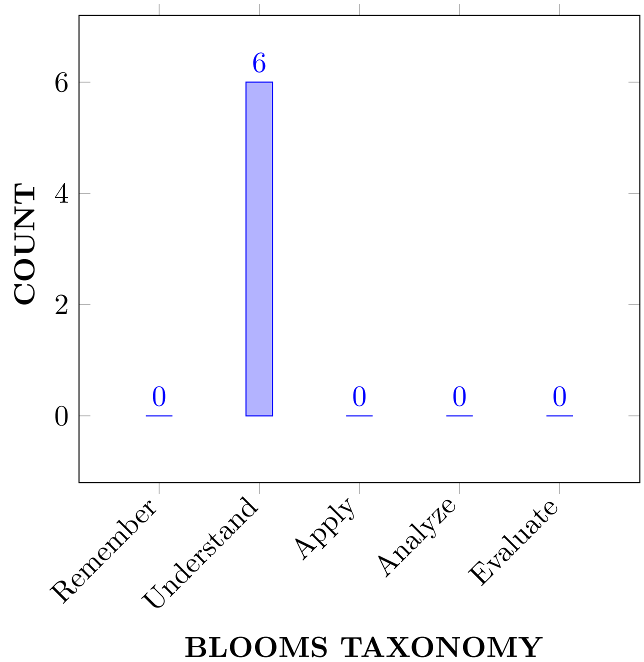
REFERENCE BOOKS:

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..

MATERIALS ONLINE:

1. Cambridge online pronunciation dictionary https://dictionary.cambridge.org/
2. Cambridge online pronunciation dictionary https://dictionary.cambridge.org/
3. Repeat after us https://brycs.org/clearinghouse/3018/
4. Language lab https://brycs.org/clearinghouse/3018/
5. Oxford online videos

22. COURSE KNOWLEDGE COMPETENCY LEVEL



33. 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	CALL LAB: Introduction to pronunciation ICS LAB: Introducing self and introducing others and feedback:	CO 1	Understnad
2	CALL LAB: Introduction to phonetics, listening to English sounds, Vowel and Consonant sounds. ICS LAB: Describing a person or place or a thing using relevant adjectives – feedback	CO 1	Understnad
3	CALL LAB: Structure of syllables. ICS LAB: JAM Sessions using public address system	CO 2	Understnad
4	CALL LAB: Word accent and stress shifts. ICS LAB: Asking for directions and giving directions	CO 2	Understand
5	CALL LAB: Past tense and plural markers ICS LAB: Role plays on fixed expressions in various situations	CO 2	Understand
6	CALL LAB: Weak forms and strong forms ICS LAB: Extempore-Picture	CO 3	Understand
7	CALL LAB: Intonation ICS LAB: Interpretation of Proverbs and Idioms	CO 3	Understand
8	CALL LAB: Neutralization of Mother Tongue Influence (MTI) ICS LAB: Etiquette	CO 3	Understand

S.No	Topics to be covered	CO's	Reference
9	CALL LAB: Common errors in pronunciation practice through tongue twisters ICS LAB: Oral Presentations	CO 4	Understand
10	CALL LAB: Minimal pairs ICS LAB: Debates	CO 4	Understand
11	CALL LAB: Listening comprehension ICS LAB: Group discussion	CO 4	Understand
12	CALL LAB: Demonstration on how to write leaflets, messages and notices. ICS LAB: Techniques and methods to write summaries and reviews of videos	CO 5	Understand
13	CALL LAB: Pronunciation practice ICS LAB: Information transfer	CO 5	Understand
14	CALL LAB; Open Ended Experiments-Phonetics Practice ICS LAB: Providing reviews and remarks	CO 6	Understand
15	CALL LAB: Open Ended experiments-Text to Speech. ICS LAB: Writing slogan related to the image	CO 6	Understand

23. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

Program Specific 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 Specific 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
Program Specific Outcomes	
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.

24. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		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	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	5	CIE/Quiz/AAT

25. 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

26. 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	-	-	-	-	-	-	-	-	✓	✓	-	-	-	-	-

27. 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 significance of individual learning and the advantages of being a team member and also develop leadership qualities.	5
CO 2	PO 9, PO 10	Demonstrate about roleplays and its impact to enhance fluency levels. Strengthen word accent and stress shifts while doing group discussions.	3, 5
CO 3	PO 9, PO 10	Use intonation in connected speech while participating debates. Identify the number syllables in words and pronounce them as a native speaker.	3, 5
CO 4	PO 10	Pronouns the sentences within the tone boundaries maintaining the melody of the language	3

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 5	PO 10	Interpret writing leaflets, messages and notices like a professional.	5
CO 6	PO 9, PO 10	Explain the procedure of preparing for interviews and academical oral presentations. Besides, recognising English speech sounds in order to maintain speaking efficiency	3, 5

28. 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	-	-	-	-	-	-	-	-	3	5	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	3	5	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	3	5	-	-	-	-	-

29. 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	100	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	100	100	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	100	100	-	-	-	-	-

30. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

2 - 40 % $< C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

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

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

31. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

32. ASSESSMENT METHODOLOGY INDIRECT:

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

15. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1		
2		
3		

4		**E**nglish language has become linguafranca across the globe. For that reason, it is compulsory to learn this language at advanced level. In MNC commpanies, those who have excellent communication skills ,their carrer graph is going to high very quickly. Hence ,the role of English language has become a part of the life.
5		
6		
7		
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9		
10		
11		

12		
13		
14		
15		
16		
17		

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD**
Dr Jan Mohmad Pandit, Assistant Professor

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

COURSE TEMPLATE

1	Department	**MECHANICAL ENGINEERING**			
2	Course Code	AEED03			
3	Course Title	**ELECTRICAL AND ELECTRONICS ENGINEERING LAB**			
4	Semester	I			
5	Regulations	BT-23			
6	Structure of the course	Practical			
		Lecture Hours		Practical Hours	
		-		36	
7	Course Offered	Odd Semester ✓		Even Semester ×	
8	Course Coordinator	Mr. G.Viswanath			
9	Date Approved by BOS	24/08/2023			
10	Course Webpage	https://www.iare.ac.in/sites/default/files/BT23/AEED03.pdf			
11	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**
		Intermediate	-	-	Physics

12. Course Overview

This course serves as a foundation course on electrical engineering. It covers a broad range of fundamental electrical circuits and devices. The concepts of current, voltage, power, basic circuit elements, electrical and electronic devices and their application in more complex electrical systems are to be imparted to the students

13. Course Objectives:

The students will try to learn:

I	The basic laws for different circuits.
II	The elementary experimental and modeling skills for handling problems with electrical machines in the industries and domestic applications to excel in professional career.
III	The intuitive knowledge needed to test and analyze the performance leading to design of electric machines by conducting various tests and calculate the performance parameters.
IV	Gain knowledge on semiconductor devices like diode and transistor

14. Course Outcomes:

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

CO1	**D**emonstrate an electric circuit by proving laws and solving theorems	Understand
CO2	**I**dentify the performance characteristics of DC shunt motor by suitable test.	Apply
CO3	**D**iscuss the performance of induction generator to study magnetizing characteristics.	Apply
CO4	**A**cquire basic knowledge on the working of diodes and rectifiers to study their characteristics.	Understand
CO5	**I**dentify transistor configuration to deduce its working characteristics.	Apply
CO6	**U**se of half wave and full wave rectifiers to study the characteristics.	Understand

15. Employability Skills

1. **Innovative Thinking:** This course helps the students to think innovative through different experiments and tests.
2. **Technological Knowledge:** Here they gain technical knowledge on electrical equipment.
3. **Safety awareness:** Students get holistic safety awareness about electricity which is very important for anyone.

16. Content Delivery / Instructional Methologies:

✓	Day to Day lab evaluation	✓	Demo Video	✓	Viva Voce questions	x	Open Ended Experiments
x	Competitions	x	hackathons	x	Certifications	✓	Probing Further Questions

17. Evaluation Methodology:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks for internal assessment, continuous lab assessment will be done for 20 marks for the day today's performance including viva voce, 10 marks for the final internal lab assessment, and the remaining 10 marks for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) AppDevelopment (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment-during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report/Project and Presentation.

Table 1.0: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

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.

Table 2.0: Experiment based

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

Table 3.0: Programming based

Objective	Analysis	Design	Conclusion	Viva voce	Total

Semester End Examination:

The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.

In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

18. Course Content:

CO 1	**Solve the source resistance, cu'rrents, voltage and power using various laws associated with electrical circuits.**
	1. Introduction to electrical circuits 2. Exercises on Basic Electrical Circuit Law's 3. Exercises on Mesh Analysis 4. Exercises on Nodal Analysis
CO 2	**Analyze open circuit characteristics of DC Shunt Generator**
	1. Observe the voltage build up, critical field resistance, critical speed
CO 3	**Perform Open circuit and Short Circuit tests on single phase transformer to observe efficiency**
	1. Conduct Open circuit and Short circuit tests on Transformer
CO 4	**Demonstrate Thevenin's and Norton's theorems to reduce complex networks into simple equivalent networks with DC excitation**
	1. Exercises on Thevenin's Theorem 2. Exercises on Norton's Theorem
CO 5	**Apply Faraday's laws of electromagnetic induction for calculating the various performance parameters in magnetic circuits.**
	1. Exercises on Determination of Circuit Impedance 2. Exercise on Series and Parallel Resonance
CO 6	**Use the connecting wires of good continuity, short circuit of connecting wire leads damage of circuit parameters.**
	1. Exercise on Z and Y Parameters 2. Exercise on H and ABCD Parameters

19. 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	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	
2	Introduction to electrical circuits	CO 1	T1:2.1 R1:1.12.3
3	Exercises on Basic Electrical Circuit Law's	CO 1	T1:1.12-1.18 R1:1.15
4	Exercises on Mesh Analysis	CO 1	T1:5.1-5.2 R1:1.16
5	Exercises on Nodal Analysis	CO 2	T1:5.3 R1:1.13.1
6	Exercises on Characteristics of Periodic Waveforms	CO 3	T1:2.4 R1:1.13.2
7	Exercises on Determination of Circuit Impedance	CO 5	T1:2.4 R1:1.13.3
8	Exercises on Thevenin's Theorem.	CO 4	T1:5.1-5.2 R1:1.7.1
9	Exercises on Norton's Theorem	CO 4	T1:5.3 R1:1.17.3
10	Exercises on Superposition Theorem	CO 3	T1:5.3 R1:2.6.1
11	Exercises on Reciprocity Theorem	CO 3	T1:5.7 R1:2.6.2
12	Exercise on Series and Parallel Resonance	CO 5	T1:1.3-1.8 R1:2.10
13	Exercise on Maximum Power Transfer Theorem	CO 3	T1:8.12-8.14
14	Exercise on Half Wave Rectifier	CO 6	T1:8.12-8.14
15	Exercise on Full Wave Rectifier	CO 6	T1:8.12-8.14

20 Experiments for Enhanced Learning (EEL):

S.No	Design Oriented Experiments
1	To study the Speed Control methods of D.C. motor
2	To study the Rectifier working and it's characteristics

21. Program Outcomes & Program Specific 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

Program Outcomes	
Program Specific Outcomes	
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

22. 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 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	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

23. 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	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

24. Mapping of each CO with PO(s),PSO(s):

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

25. 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 basics of mathematics, engineering sciences and other sciences to understand the concept of DC and AC Circuits.	3
	PO 2	Validate the principles of different laws associated with electrical circuits from obtained principles using basics fundamentals of mathematics and engineering sciences.	3
	PO 5	Validate the principles of different laws associated with electrical circuits using digital simulation	1
	PO 10	Improve the documentation skills for their problem-solving approaches, calculations, and findings, resulting in well-structured and informative reports	1
CO 2	PO 1	Recall the basics of mathematics, engineering sciences and other sciences to understand the concept of Kirch- hom's laws	3

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 2	Analyze mesh analysis and nodal analysis technique using principles of mathematics, science and engineering fundamentals	5
	PO 5	Analyze mesh analysis and nodal analysis technique using digital simulation	1
	PO 10	Improve the documentation skills for their problem-solving approaches, calculations, and findings, resulting in well-structured and informative reports	1
CO 3	PO 1	Apply the basics of mathematics, engineering sciences and other sciences to understand the network theorems	3
	PO 2	Describes the different Theorems with AC andDC excitation from obtained principles using basics fundamentals of mathematics and engineering sciences.	5
	PO 5	Construct various electrical circuits to validate Theorems with DC excitation using digital simulation	1
	PO 10	Improve the documentation skills for their problem-solving approaches, calculations, and findings, resulting in well-structured and informative reports	1
CO 4	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals to the solution of magnetic circuits	3
	PO 2	Describes the fundamental characteristics of electromagnetic induction, self and mutual inductance in the single coil and coupled coils magnetic circuits using basics fundamentals of mathematics and engineering sciences.	5
	PO 5	Construct various electrical circuits to validate Thevenin's and Norton's theorems using digital simulation	1
	PO 10	Improve the documentation skills for their problem-solving approaches, calculations, and findings, resulting in well-structured and informative reports	1
CO 5	PO 1	Recall the basics of mathematics, engineering sciences and other sciences to understand the concept of two port network and graph theory.	3
	PO 2	Validate the principles of different parameters and network topology from obtained principles using basics fundamentals of mathematics and engineering sciences.	5
	PO 5	Validate the principles of different parameters and network topology using digital simulation.	1

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	P0 10	Improve the documentation skills for their problem-solving approaches, calculations, and findings, resulting in well-structured and informative reports	1
CO 6	PO 1	Identify complex engineering problems on two port network and graph theory using first principles of mathematics, natural sciences, and engineering sciences.	3
	PO 2	Recall the basics of mathematics, engineering sciences and other sciences to understand the concept of duality.	5
	PO 5	Determine the H and ABCD parameters for Circuit using digital simulation.	1
	P0 10	Improve the documentation skills for their problem-solving approaches, calculations, and findings, resulting in well-structured and informative reports	1

26. 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	-	-	1	-	-	-	-	3	-	-	-	-	-
CO 2	3	5	-	-	1	-	-	-	-	3	-	-	-	-	-
CO 3	3	5	-	-	1	-	-	-	-	3	-	-	-	-	-
CO 4	3	5	-	-	1	-	-	-	-	3	-	-	-	-	-
CO 5	3	5	-	-	1	-	-	-	-	3	-	-	-	-	-
CO 6	3	5	-	-	1	-	-	-	-	3	-	-	-	-	-

27. 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	-	-	100	-	-	-	-	60	-	-	-	-	-
CO 2	100	50	-	-	100	-	-	-	-	60	-	-	-	-	-
CO 3	100	50	-	-	100	-	-	-	-	60	-	-	-	-	-
CO 4	100	50	-	-	100	-	-	-	-	60	-	-	-	-	-
CO 5	100	50	-	-	100	-	-	-	-	60	-	-	-	-	-
CO 6	100	50	-	-	100	-	-	-	-	60	-	-	-	-	-

28. Course articulation matrix (PO – PSO mapping):

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

0 - 0≤ C≤ 5% – No correlation

2 - 40 % <C < 60% –Moderate

1-5 <C≤ 40% – Low/ Slight

3 - 60% ≤ C < 100% – Substantial /High

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

29. Assessment methodology direct:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

30. Assessment methodology indirect:

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

31. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1		
2		

3	GOOD HEALTH AND WELL-BEING	
4	QUALITY EDUCATION	**Quality Education:** This subject will improve the quality education in engineers and gives the awareness in electrical usage in day-to-day life.
5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	
7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	

12		**Responsible Consumption and Production** This subject impacts the demand of electricity and need for saving energy
13		
14		
15		
16		
17		

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD,EEE**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**MECHANICAL ENGINEERING**			
2	Course Title	**OBJECT ORIENTED PROGRAMMING WITH JAVA**			
3	Course Code	ACSD02			
4	Program	B.Tech			
5	Semester	I Semester			
6	Regulation	BT-23			
7	Structure of the course	Practical			
		Tutorial Hours		Practical Hours	
		1		2	
8	Course Offered	Odd Semester ✓		Even Semester ×	
9	Course Coordinator	Mr. D. Atchuta Ramacharyulu			
10	Date Approved by BOS	25/08/2023			
11	Course Webpage	www.iare.ac.in/—-/—-			
12	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**
		-	-	-	-
		-	-	-	-

13. COURSE OVERVIEW

This course provides a solid foundation in object-oriented programming concepts and hands-on experience in using them. It introduces the concepts of abstraction and reusable code design via the object-oriented paradigm. Through a series of examples and exercises students gain coding skills and develop an understanding of professional programming practices. Mastering Java facilitate the learning of other technologies.

14. COURSE OBJECTIVES

The students will try to learn:

I	The strong foundation with the Java Virtual Machine, its concepts and features.
II	The systematic understanding of key aspects of the Java Class Library
III	The usage of a modern IDE with an object oriented programming language to develop programs.

15. COURSE OUTCOMES

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

CO 1	Develop non-trivial programs in an modern programming language.
CO 2	Apply the principles of selection and iteration.
CO 3	Appreciate uses of modular programming concepts for handling complex problems.
CO 4	Recognise and apply principle features of object-oriented design such as abstraction and encapsulation.
CO 5	Design classes with a view of flexibility and reusability.
CO 6	Code, test and evaluate small usecases to conform to a specification.

16. EMPLOYABILITY SKILLS

1. **Problem-Solving and Critical Thinking:** Students learn to analyze complex problems, design solutions using Java's object-oriented principles, and translate real-world scenarios into code.
2. **Debugging and Troubleshooting:** Debugging challenges in the lab help students master error identification, interpretation, and use of debugging tools, essential for real-world software development.

17. CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES

✓	Day to Day lab evaluation	✓	Demo Video	✓	Expected Viva Voce questions	✓	Open Ended Experiments
X	Competitions	X	hackathons	✓	Certifications	✓	Probing Further Questions

18. EVALUATION METHODOLOGY

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

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.

Table 4: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
					20

Table 5: Programming based

Objective	Analysis	Program	Results	Viva voce	Total
4	4	6	4	2	20

Semester End Examination:

The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.

In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

19. COURSE CONTENT

CO 1	**Develop non-trivial programs in an modern programming language.**
	1. Getting Started Exercises 2. Exercises on Number Systems (for Science/Engineering Students)
CO 2	**Apply the principles of selection and iteration.**
	1. Exercises on Decision and Loop 2. Exercises on Input, Decision and Loop 3. Exercises on Nested-Loops (Patterns) 4. Magic(Special) Numbers 5. Exercises on String and char Operations 6. Exercises on Arrays
CO 3	**Appreciate uses of modular programming concepts for handling complex problems.**
	1. Exercises on Methods 2. Exercises on Command-line Arguments and Recursion 3. More (Difficult) Exercises
CO 4	**Recognise and apply principle features of object-oriented design such as abstraction and encapsulation.**
	1. Exercises on Classes and Objects
CO 5	**Design classes with a view of flexibility and reusability.**
	1. Exercises on Inheritance
CO 6	**Code, test and evaluate small usecases to conform to a specification.**
	1. Exercises on Polymorphism, Abstract Classes and Interfaces

Note: One Course Outcome may be mapped to multiple number of experiments.

Text Books

1. Farrell, Joyce.“*Java Programming*”, Cengage Learning B S Publishers, 8th Edition, 2020
2. Schildt, Herbert. ”*Java: The Complete Reference*” 11th Edition, McGraw-Hill Education, 2018.

Reference Books

1. Deitel, Paul and Deitel, Harvey. "*Java: How to Program*", Pearson, 11th Edition,2018.
2. Evans, Benjamin J. and Flanagan, David. "*Java in a Nutshell*", O'Reilly Media, 7th Edition, 2018.
3. Bloch, Joshua. "*Effective Java*", Addison-Wesley Professional, 3rd Edition, 2017.
4. Sierra, Kathy and Bates, Bert. "*Head First Java*", O'Reilly Media, 2nd Edition, 2005.

Materials Online

1. https://docs.oracle.com/en/java/
2. https://www.geeksforgeeks.org/java
3. https://www.tutorialspoint.com/java/index.htm
4. https://www.coursera.org/courses?query=java

20. COURSE PLAN

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

S.No	Topics to be covered	CO's
1	Getting Started Exercises	CO 1
2	Exercises on Number Systems (for Science/Engineering Students)	CO 1
3	Exercises on Decision and Loop	CO 2
4	Exercises on Input, Decision and Loop	CO 2
5	Exercises on Nested-Loops (Patterns)	CO 2
6	Magic(Special) Numbers	CO 2
7	Exercises on String and char Operations	CO 2
8	Exercises on Arrays	CO 2
9	Exercises on Methods	CO 3
10	Exercises on Command-line Arguments, Recursion	CO 3
11	More (Difficult) Exercises	CO 3
12	Exercises on Classes	CO 4
13	Exercises on Inheritance	CO 5
14	Exercises on Polymorphism, Abstract Classes and Interfaces	CO 6

Experiments for enhanced learning (EEL):

S.No	Design Oriented Experiments
1.	Given an array of integers nums and an integer target, return indices of the two numbers such that they add up to target.
2.	Given a sorted array of distinct integers and a target value, return the index if the target is found. If not, return the index where it would be if it were inserted in order.
3.	Given a roman numeral, convert it to an integer.

4.	Implement the myAtoi(string s) function, which converts a string to a 32-bit signed integer
5.	Given a string s, find the length of the longest substring without repeating characters.

21. PROGRAM OUTCOMES & PROGRAM SPECIFIC 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

Program Specific Outcomes	
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.

22. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	1	LAB PROGRAMS/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 PROGRAMS/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	LAB PROGRAMS/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.	3	LAB PROGRAMS/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 PROGRAMS/CIE/SEE
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	3	LAB PROGRAMS/CIE/SEE

23. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 3	Make use of modern computer tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2	LAB PROGRAMS/CIE/SEE

3 = High; 2 = Medium; 1 = Low

24. 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	-	✓	-	-	-	✓	-	✓	-	-	-	-	-	-	-

25. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	1
	PO 5	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
	PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	1

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 2	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	1
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	7
CO 3	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	7
	PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	4
CO 4	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	7
	PO 3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	6
CO 5	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	7
	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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 6	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	7
	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
	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	4

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

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	33.3	-	-	-	100	-	-	-	-	-	-	-	-	-	33.33
CO 2	33.3	70	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	33.3	70	-	-	-	-	-	-	-	-	-	-	-	-	33.33
CO 4	-	70	60	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	70	-	-	-	20	-	-	-	-	-	-	-	-	-
CO 6	-	70	-	-	-	60	-	66.6	-	-	-	-	-	-	

28. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

2 - $40\ \% < C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

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

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

29. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

30. ASSESSMENT METHODOLOGY INDIRECT:

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

31.RELEVANCE TO SUSTAINABILITY GOALS

Write brief description about the course and how its relevance to SDGs.

X		
X		
X		

✓	QUALITY EDUCATION	**Quality Education:** The students can gain a deeper understanding of how technology can be harnessed to address global challenges. This promotes quality education by fostering critical thinking and problem-solving skills in the context of sustainable development.
X	GENDER EQUALITY	
X	CLEAN WATER AND SANITATION	
X	AFFORDABLE AND CLEAN ENERGY	
X	DECENT WORK AND ECONOMIC GROWTH	
✓	INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Industry, Innovation, and Infrastructure:** Java programming skills are essential for developing innovative software solutions. Students working on projects related to sustainable development can contribute to building resilient infrastructure and promoting inclusive and sustainable industrialization.
X	REDUCED INEQUALITIES	
✓	SUSTAINABLE CITIES AND COMMUNITIES	**Sustainable Cities and Communities:** Java programming plays a crucial role in developing applications for smart cities, efficient transportation, and waste management systems. Through projects in the lab, students can explore ways to create more sustainable urban environments.

X	RESPONSIBLE CONSUMPTION AND PRODUCTION	
✓	CLIMATE ACTION	**Climate Action:** Students can create climate-related applications, such as carbon footprint calculators or climate data analysis tools, using Java programming. This directly contributes to SDG 13 by raising awareness and facilitating climate action.
X	LIFE BELOW WATER	
X	LIFE ON LAND	
X	PEACE, JUSTICE AND STRONG INSTITUTIONS	
✓	PARTNERSHIPS FOR THE GOALS	**Partnerships for the Goals:** Collaborative projects can foster partnerships among students, educators, and local communities. These partnerships enhance knowledge sharing and the development of innovative solutions that align with multiple SDGs.

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD,ME**
Mr. D. Atchuta Ramacharyulu, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

<table>
<tr><td>1</td><td>Department</td><td colspan="4">MECHANICAL ENGINEERING</td></tr>
<tr><td>2</td><td>Course Code</td><td colspan="4">AMED01</td></tr>
<tr><td>3</td><td>Course Title</td><td colspan="4">ENGINEERING WORKSHOP</td></tr>
<tr><td>4</td><td>Semester</td><td colspan="4">I Semester</td></tr>
<tr><td>5</td><td>Regulation</td><td colspan="4">BT-23</td></tr>
<tr><td rowspan="3">6</td><td rowspan="3">Structure of the course</td><td colspan="4">Practical</td></tr>
<tr><td colspan="3">Lecture Hours</td><td>Practical Hours</td></tr>
<tr><td colspan="3">–</td><td>2</td></tr>
<tr><td>7</td><td>Course Offered</td><td colspan="2">Odd Semester ✓</td><td colspan="2">Even Semester ×</td></tr>
<tr><td>8</td><td>Course Coordinator</td><td colspan="4">Dr. S Sathees Kumar</td></tr>
<tr><td>9</td><td>Date Approved by BOS</td><td colspan="4">24/08/2023</td></tr>
<tr><td>10</td><td>Course Webpage</td><td colspan="4">https://www.iare.ac.in/?q=pages/btech-course-syllabi-bt23-me</td></tr>
<tr><td rowspan="2">11</td><td rowspan="2">Course Prerequistes</td><td>Level</td><td>Course Code</td><td>Semester</td><td>Prerequisites</td></tr>
<tr><td>–</td><td>–</td><td>–</td><td>No prerequisites</td></tr>
</table>

12. Course Overview:

This course provides the opportunity to become confident with new tools, equipment, and techniques for creating physical objects and mechanisms with a variety of materials. The students will learn principles of contemporary trends in manufacturing processes, such as CNC machining and 3D printing, as well as gain practical experience in carpentry, fitting, and welding. Skills learned in the course enable the students to learn about the design process in digital manufacturing used in various industrial applications.

13. Course objectives:

The students will try to learn:

I	The basics and hands-on practice of carpentry, fitting, and welding.
II	The impart knowledge and skill to use tools, equipment, measuring instruments, and modern techniques.
III	The concepts of manufacturing process by casting, moulding and forging.
IV	The basic machining operations by CNC lathe, CNC milling, and 3D printing machine.

14. Course outcomes:

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

CO 1	**Select** appropriate tools, work material and measuring instruments useful for carpentry, fitting, and welding.	Apply
CO 2	**Use** flat sheets for sheet metal and intricate shapes made from mild steel for Black smithy.	Apply
CO 3	**Choose** appropriate components and tools to prepare pipe fitting and joints of specific shapes and sizes.	Apply
CO 4	**Experiment** with the moulding techniques for producing cast components in complex shapes using different patterns.	Apply
CO 5	**Execute** hard soldering techniques to join similar and dissimilar materials used in industries. .	Understand
CO 6	**Demonstrate** appropriate equipment and methods for various machining processes used in CNC machines and 3D printing for manufacturing industries.	Understand

15. Employability Skills:

1. **Project based skills:** This can provide knowledge about engineering tools used in the manufacturing of products as well as project-based skills.
2. **Programming skills:** Modern manufacturing techniques (CNC programming) will be useful for project and product-based skills.

16. Content delivery / Instructional methologies:

✓	Day to Day lab evaluation	x	Demo Video	✓	Viva Voce questions	✓	Open Ended Experiments
x	Competitions	x	hackathons	x	Certifications	✓	Probing Further Questions

17. Evaluation methodology:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

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.

Table 4: Experiment based

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

Table 5: Programming based

Objective	Analysis	Design	Conclusion	Viva voce	Total
–	–	–	–	–	20

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

18. Course content:

CO 1	**Select appropriate tools, work material and measuring instruments useful for carpentry, fitting, and welding**
	1. Preparation of the cross-half lap joint. 2. Preparation of the dove tail joint. **Try** 1.1 Preparation of the mortise and tenon joint as per the following dimensions. Width = 50 mm and tenon thickness = 10 mm. 1.2 Preparation of the end lap joint as per the following dimensions. The end lap projection dimensions to be taken into consideration are width = 50 mm and thickness = 15 mm. 3. Making of a square fitting using mild steel plates. 4. Making of a V-fit according to the size of the provided mild steel plates. **Try** 1.3 Straight fitting of mild steel plates to the specified sizes. 1.4 Making of semicircular fit with mild steel plates. 5. Creating the lap joint in accordance with the mild steel plates. 6. Making the butt joint using the mild steel plates. **Try** 1.5 Construction of the tee joint using the mild steel plates provided. 1.6 Creating the corner (L) joint using the provided mild steel plates.
CO 2	**Use flat sheets for sheet metal and intricate shapes made from mild steel for Black smithy.**
	1. Preparation of the rectangular tray as per the dimensions. 2. Prepare the developing surface and create cylindrical tin. **Try** 2.1 Construct the open scoop as per the given GI sheet specificatios. 2.2 Making of the hexagonal prism using GI sheet. 3. Make the s-hook using the given mild steel rod. 4. Construct the J-hook using the given mild steel rod. **Try** 2.3 Create the C - hook with the given mild steel rod. 2.4 Prepare the U - bend with the given mild steel rod.

CO 3	**Choose appropriate components and tools to prepare pipe fitting and joints of specific shapes and sizes.**
	1. Form of PVC pipe fitting through various components. 2. Form of GI pipe fitting with various components. **Try** 3.1 Form of PVC pipe fitting with reducer for water tap with different components. 3.2 Form of GI pipe fitting with different components for different fluids.
CO 4	**Experiment with the moulding techniques for producing cast components in complex shapes using different patterns.**
	1. Making of flange mould using a given pattern. 2. Utilizing the provided pattern, create the bearing housing mould. **Try** 4.1 Making of dumble using a given pattern. 4.2 Using a single-piece pattern, create a one-stepped shaft . 3. Preparation of concrete cube by moulding technique. 4. Demonstration on plaster of paris mould making. **Try** 4.3 Preparation of any house hold specimens by plaster of paris mould making. 4.4 Preparation of any intricate article by plaster of paris mould making.
CO 5	**Execute hard soldering techniques to join similar and dissimilar materials used in industries.**
	1. Soldering of two mild steel plates. 2. Hard soldering of engine valve tappet. **Try** 5.1 Hard soldering of copper with brass material. 5.2 Hard soldering of stainless steel with brass.
CO 6	**Demonstrate appropriate equipment and methods for various machining processes used in CNC machines and 3D printing for manufacturing industries.**
	1. Demonstration of the plain turning and facing opeartions on a CNC lathe 2. Demonstration of plain milling (facing) and precision slotting on CNC milling. 3. Demonstration of 3D printing machine using Acrylonitrile butadiene styrene (ABS) and Polylactic acid (PLA) material. 4. Demonstration of the 6 – axis aristo robot and aristo sim software. 5. Demonstration of shaft grinding process on a cylindrical grinding machine.

TEXTBOOKS

1. S.K.Hajra Choudhury, A.K.Hajra Choudhury A.K. and S.K.Nirjhar Roy, "*Elements of Workshop Technology*", Media promoters and publishers private limited, Mumbai, 4th Edition ,2020.
2. S.Kalpakjian, Steven S. Schmid, "*Manufacturing Engineering and Technology*", Pearson Education India Edition, 7th Edition, 2019.

REFERENCE BOOKS:

1. Gowri P. Hariharan, A. Suresh Babu, "*Manufacturing Technology – I*", Pearson Education,5thEdition , 2018.
2. Roy A. Lindberg, "*Processes and Materials of Manufacture*", Prentice Hall India, 4th Edition, 2017.

MATERIALS ONLINE:

1. Lab manual
2. Question bank

19. 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 of the cross half-lap joint and dove tail joint.	CO 1	R1:11.1-11.5
2	Making of square fitting and V –fit using mild steel plates.	CO 1	R1:4.8,R1:7.2
3	Creating a lap joint and butt joint by welding.	CO 1	R1:6.3-6.52
4	Creating the rectangular tray and cylindrical tin using GI sheet	CO 2	R1:10.1-10.2
5	Prepare the s-hook and j-hook with the given mild steel rods.	CO 2	R2:12.6, R1:5.2
6	Form of PVC and GI pipe fitting through various components.	CO 3	R1:9.3-9.5
7	Making of flange mould and bearing housing mould using a given pattern.	CO 4	R2:10.4-10.7
8	Preparation of concrete/cement cube and demonstration of plaster of paris moulding technique	CO 4	R2:3.12
9	Hard soldering of ferrous and nonferrous materials	CO 5	R1:2.18
10	Demonstration of the CNC lathe machining process	CO 6	R2:13.8 - 13-11
11	Demonstration of the CNC milling process.	CO 6	R2:14.2-14-6
12	Demonstration of 3D printing machine using different materials.	CO 6	R1:17.4-17-5
13	Demonstration of the 6-axis robot.	CO 6	R1:15.3-15-5
14	Demonstration of the cylindrical grinding machine.	CO 6	R2:9.5-9-7

20. Experiments for enhanced learning (EEL):

S.No	Product 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	**hard soldering:** Metals and alloys of dissimilar compositions can be hard-soldered (brazed or silver-soldered) together, for example: copper to brass; copper to steel; brass to steel; cast iron to mild steel; and mild steel to stainless steel.
4	**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.
5	**Concrete cube:** Plastic or Steel Concrete Cube Moulds are used to form specimens for concrete compressive strength testing. They can also be used as sample containers in the determination of mortar set times as indicated in ASTM C403 and AASHTO T 197.

21. Program Outcomes and Program Specific 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
Program Specific Outcomes	
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 start-ups, employability and higher studies.

22. 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
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.	3	Lab Exercises
PO 6	**The Engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	Lab Exercises

PO 7	**Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	3	Lab Exercises
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	1	Lab Exercises
PO 9	**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	1	Lab Exercises
PO 12	**Life-Long Learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change..	1	Lab Exercises / CIE /SEE

23. 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	Lab Exercises / CIE / SEE
PSO 3	Make use of computational and experimental tools for building career paths towards innovation startups, employability and higher studies.	3	Lab Exercises / CIE / SEE

3 = High; 2 = Medium; 1 = Low

24. 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	✓	-	-	-	✓	-	✓	-	-	-	-	✓	✓	-	✓

25. 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 science, mathematics and engineering fundamentals to select the proper tools and machines for making wood and metal works	3
	PO 6	Acquire the knowledge of maintaining safety regulations on the shop floor.	1
CO 2	PO 1	Apply the knowledge of mathematics and engineering fundamentals to develop rectangular trays and round tins.	2
	PO 6	Obtain knowledge about safety precautions in forging techniques.	1
CO 3	PO 1	Apply the basics of mathematics to measure the pipes and use engineering concepts for appropriate joints.	2
	PO 8	Acquire awareness of the norms of the engineering practice.	1
CO 4	PO 1	Apply the science and engineering knowledge to prepare the casting of complex shapes.	2
	PO 7	Understand the impact of professional engineering solutions in societal and environmental contexts.	2
CO 5	PO 1	Apply the science and engineering knowledge to make hard soldering in dissimilar materials.	2
	PO 6	Obtain knowledge about safety precautions in hard soldering techniques.	1
	PO 9	Function effectively as an individual and as a member in solder making of non ferrous/ ferrous materials.	1
CO 6	PO 1	Apply the science, mathematics and engineering knowledge to understand the concepts of digital manufacturing	3
	PO 5	Identify and select appropriate machines with modern techniques for the machining process.	1
	PO 7	Demonstrate their knowledge of recent trends in manufacturing, the need for sustainable development, and the impact of professional engineering solutions on society	2
	PO 12	Use life-long learning in the broadest context of recent trends in manufacturing domains.	1
	PSO 1	Attain knowledge and ideation towards digital manufacturing in product development and additive manufacturing techniques	2
	PSO 3	Make use of digital manufacturing demonstrations to build career paths towards employability and higher studies.	2

26. 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	-	-	-	-	-		-	-	-
CO 2	2	-	-	-	-	1	-	-	-	-	-	-	-	-	-
CO 3	2	-	-	-	-	-	-	1	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	2	-	-	-	-	-	-	-	-
CO 5	2	-	-	-	-	1	-	-	1	-	-	-	-	-	-
CO 6	3	-	-	-	1	-	2	-	-	-	-	1	2	-	2

27. Percentage of key competencies 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	-	-	-	-	20	-	-	-	-	-		-	-	-
CO 2	66	-	-	-	-	20	-	-	-	-	-	-	-	-	-
CO 3	66	-	-	-	-	-	-	33	-	-	-	-	-	-	-
CO 4	66	-	-	-	-	-	66	-	-	-	-	-	-	-	-
CO 5	66	-	-	-	-	20	-	-	8.3	-	-	-	-	-	-
CO 6	100	-	-	-	100	-	66	-	-	-	-	12.5	100	-	100

28. Course articulation matrix PO / PSO mapping:

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

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

2 - 40 % <C < 60% –Moderate

1-5 <C$\leq$ 40% – Low/ Slight

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

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

29. Assessment methodology -Direct:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

30. Assessment methodology -Indirect:

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

31. Relevance to Sustainability goals (SDGs):

Write brief description about the course and how its relevance to SDGs.

1	NO POVERTY	
2	ZERO HUNGER	
3	GOOD HEALTH AND WELL-BEING	
4	QUALITY EDUCATION	**Quality Education:** The engineering workshop course provides students with a strong foundation and allows them to apply knowledge about engineering tools used in manufacturing of products.
5	GENDER EQUALITY	

6	CLEAN WATER AND SANITATION	
7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	**Responsible Consumption and Production:** Focusing on efficient material use and waste reduction in engineering workshops can aid in the developing of components/products.
13	CLIMATE ACTION	
14	LIFE BELOW WATER	

15		
16		
17		

Approved by: Board of Studies in the meeting conducted on 24.08.2023.

Signature of Course Coordinator **HOD,ME**
Dr. S Sathees Kumar, Associate Professor

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

COURSE TEMPLATE

1	Department	**MECHANICAL ENGINEERING**				
2	Course Title	**ENGINEERING CHEMISTRY**				
3	Course Code	AHSD03				
4	Program	B.Tech				
5	Semester	II Semester				
6	Regulation	BT-23				
7	Structure of the course	Theory			Practical	
		Lecture 3	Tutorials 0	Credits 3	Lab -	Credits -
8	Type of course (**Tick type of course**)	Core ✓	Professional Elective -	Open Elective -	VAC -	MOOCs -
9	Course Offered	Odd Semester ✓		Even Semester ×		
10	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: 64 hours		Tutorials: .... hours		Practical: .... hours	
11	Course Coordinator	Dr.V Anitha Rani				
12	Date Approved by BOS	24/08/2023				
13	Course Webpage	https://www.iare.ac.in/sites/default/files/BT23/AHSD03.pdf				
14	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**	
		Intermediate	-	-	-	
		B.Tech	-	-	-	

15. Course Overview

The course focuses on the fundamental concepts of chemistry to impart knowledge on applications of chemical sciences in engineering and technology. It deals with topics such as electrochemical principles in batteries, techniques to control corrosion, alternative sources of energy and water purification process. The significance of advanced materials and their usage in industrial, commercial and social sectors for sustainable development.

16. COURSE OBJECTIVES:

The students will try to learn:

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

17. COURSE OUTCOMES:

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

CO 1	**Implement** the principles of electrochemical systems to control the corrosion in metals.
CO 2	**Analyze** the basic properties of water for its usage in domestic and industrial purposes.
CO 3	**Use** complexometry for calculation of hardness of water to avoid industrial problems.
CO 4	**Extend** the applications of polymers based on their degradability and properties..
CO 5	**Choose** the appropriate fuel based on their calorific value for energy efficient processes.
CO 6	**Predict** the knowledge on viability of advanced materials for technological improvements in various sectors.

18. Topic Learning Outcome (TLOs):

SNo	TOPIC(S)	TLO No	Topic Learning Outcome's	Course Out-come:	Blooms Level
1	Galvanic cell	TLO 1	Recall the oxidation and reduction reactions by observing the chemical changes in a cell.	CO 1	Remember
		TLO 2	Explain the operation of electrochemical cell to produce electrical energy from spontaneous redox reactions..	CO 1	Understand
		TLO 3	Use electrochemical principles in batteries.	CO 1	Apply

SNo	TOPIC(S)	TLO No	Topic Learning Outcome's	Course Out-come:	Blooms Level
2	Electrolytic cell	TLO 4	Illustrate the process of electrolysis by using electrical energy for non-spontaneous chemical reactions..	CO 1	Understand
		TLO 5	Use electrolysis process in separating or obtaining pure elements from ores.	CO 1	Apply
3	Electrochemical series	TLO 6	Interpret the degree of reactivity of electrodes based on activity series table with standard hydrogen electrode.	CO 1	Understand
		TLO 7	Use standard reduction potential data to determine the relative strength of oxidizing and reducing agents.	CO 1	Apply
4	Zinc-air battery	TLO 8	Discuss the chemical reactions in Zinc and oxygen to produce electrical energy.	CO 1	Understand
5	Lead-Acid battery and Li-ion battery	TLO 9	Relate the relationship between charge produced and the amount of product formed for both electrochemical cell and electrolytic cells.	CO1	Understand
6	Causes of corrosion	TLO 10	Recall the corrosion process in metals in presence of environment.	CO 1	Understand
7	Chemical Corrosion	TLO 11	Interpret the oxidation and reduction reactions on the surface of metal in presence of oxygen to form metal oxide in presence of oxygen.	CO 1	Understand
8	Electrochemical corrosion	TLO 12	Illustrate the electrochemical corrosion of metals in acidic and alkaline environment.	CO1	Understand
9	Cathodic protection	TLO 13	Use sacrificial anodes to control corrosion inmetal structures.	CO1	Apply
10	Galvanizing, Tinning	TLO 14	Make use of metallic coatings and coating deposition technologies to prevent corrosion in metals	CO1	Apply
11	Electroplating	TLO 15	Use the process of electrolysis in industries to prevent corrosion in metals.	CO1	Apply

SNo	TOPIC(S)	TLO No	Topic Learning Outcome's	Course Outcome:	Blooms Level
12	Treatment methods of potable water, Ion-exchange process and Reverse osmosis	TLO 16	Estimate the different water treatment methods to use in industries and domestic purpose.	CO2	Understand
13	Expression of hardness	TLO 17	Select the CaCO3 equivalents to express the total, temporary and permanent hardness of water.	CO3	Apply
14	Complexometry method	TLO 18	Make use of complexometry method to calculate the hardness of water	CO3	Apply
15	Types of polymerization	TLO 19	Relate the addition and condensation polymerization process to synthesize the polymers	CO4	Understand
16	Synthetic polymers	TLO 20	Explain the properties of polymers from organiccompounds.	CO4	Understand
17	Applications of polymers	TLO 21	Use polymers in various sectors based on their properties.	CO4	Apply
18	Classification of fuels	TLO 22	Classify the different types of fuels based their physical state of aggregation.	CO5	Understand
19	Analysis of coal	TLO 23	Demonstrate the qualitative and quantitative analysis of coal to prevent problems inindustries.	CO 5	Understand
20	Refining of petroleuml	TLO 24	Illustrate the fractions of crude oil by fractional distillation process.	CO 5	Understand
21	Demonstrate the qualitative and quantitative analysis of coal to prevent problems inindustries.	TLO 25	Develop the work energy relations and apply to connected systems.	CO5	Understand
22	Gaseous fuels	TLO 26	Use Liquefied petroleum gas and Compressed natural gas in various sectors.	CO 5	Apply
23	Calorific value of fuels	TLO 26	Use the Dulong's formula to find the highercalorific value and lower calorific value of fuels	CO 5	Apply
24	Combustion of fuels	TLO 27	Use theoretical calculation of amount of air required for combustion of fuels.	CO 5	Apply

SNo	TOPIC(S)	TLO No	Topic Learning Outcome's	Course Outcome:	Blooms Level
25	Synthesis of Nanomaterials	TLO 28	Enhance the understanding of nano-structural materials	CO 6	Apply
26	Nanomaterials	TLO 29	Enhance the use of nanomaterials as a complex materials and structures in buildings.	CO 6	Apply
27	Smart materials	TLO 30	Recognize the importance and applications of smart materials.	CO 6	understand
28	Thermoresponse materials	TLO 31	Identify the importance and benefits of thermoresponse materials	CO 6	understand
29	Setting and hardening of cement	TLO 32	Relate the chemical reactions in setting and hardening of cement	CO 6	understand
30	Mechanism of lubrication	TLO 33	Discuss the mechanism of lubrication processapplied under different load, pressure andtemperatureconditions	CO6	understand

19. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
Project based skills Engineering chemistry for students based on qualitative and quantitative analysis of experimental skills.

20. Content Delivery / Instructional Methologies:

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

21. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

22. COURSE CONTENT-Number of Modules:Five

MODULE I	**BATTERIES CHEMISTRY AND CORROSION** | Number of Lectures: 13
	Introduction to electrochemical cells: electrolytic cell, Galvanic cell; electrochemical series and its applications; Batteries: classification of batteries, construction, working and applications of Zinc-air battery, Lead-acid battery, Li-ion battery, applications of Li-ion battery to electric vehicles; 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 methods; Metallic coatings: Galvanization and tinning; electroplating of Copper.
MODULE II	**WATER AND ITS TREATMENT** | **Number of Lectures: 13**
	Hardness 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	**POLYMER TECHNOLOGY** **.** |**Number of Lectures: 13**
	Polymers: classification of polymers; types of polymerization-addition, condensation polymerization withexamples. Plastics: thermoplastic and thermosetting plastics; preparation, properties and engineering applications of PVC, Nylon6,6 and Bakelite; Biodegradable polymers: polylactic acid and polyvinyl alcohol and theirapplications. Elastomers: Introduction to natural rubber, vulcanization of natural rubber, preparation, properties and engineering applications of Buna-S and Thiokol rubber.
MODULE IV	**ENERGY SOURCES** | **Number of Lectures: 13**
	Introduction to fuels; classification of fuels; Solid fuels: coal; analysis of coal, proximate and ultimate analysis and their significance; Liquid fuels: petroleum and its refining; Gaseous fuels: composition, characteristics and applications of natural gas, LPG and CNG; Alternative and non-conventional sources of energy: solar, wind and hydropower advantages and disadvantages. Calorific value of fuel: HCV and LCV, Dulongs formula, calculation of air quantity required for complete combustion of fuel, numerical problems

MODULE V	ENGINEERING MATERIALS | Number of Lectures: 12
	Nanomaterials: introduction, preparation of nanoparticles by sol-gel method, chemical reduction method, applications of nanomaterials. Smart materials and their engineering applications: shape memory materials, poly L-lactic acid. Thermoresponse materials: Polyacryl amides, Poly vinyl amides. Cement: composition of Portland cement, setting and hardening of cement. Lubricants: characteristics of a good lubricant, mechanism of lubrication, thick film, thin film and extreme pressure lubrication; properties of lubricants: viscosity, Redwood viscometer, flash and fire point, cloud and pour point.

TEXTBOOKS

1. Jain and jain, Monika jain , "*Engineering Chemistry* ", Dhanpat Rai Publishers, 17th Edition, 2022.

REFERENCE BOOKS:

1. Shashi chawla& *Engineering Chemistry*", 1th Edition, 2017.
2. jaya sree Reddy, "*Engineering Chemistry*", wiley Publications, 2023.
3. S.S Dara "*Engineering Chemistrys. chand*"12th Edition, 2018.
4. Nitin K Puri "*Nanomaterials Synthesis Properties And Applications*", I K international publishing house pvt Ltd, 1st edition 2021.
5. S. Bhavikatti, "*Engineering Chemistry*", New Age International, 5th Edition, 2020.
6. R. C. Hibbler, "*Engineering Chemistry*", Pearson Press, 2021.

MATERIALS ONLINE:

1. Lecture notes, ELRV videos and power point presentations
2. Answers / solutions to all questions / problems in the textbook
3. Online exercises
4. Problems and solutions in files

23. COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
1	Electrochemical cells (Galvanic cell), electrolytic cell	CO 1	T1:6.1, R1:7.4,8
2	Electrochemical series and its applications	CO 1	T1: 6.7, R1:10
3	Batteries, classification of batteries	CO 1	T2:5.10 R1:1.15
4	Construction, working and applications of Zinc-air battery	CO 1	T1:3.13, R1:23.1
5	Construction, working and applications of Lead-acid storage battery	CO 1	T1:3.13,R1:23.2
6	Construction, working and applications of Li-ion battery, applications of Li-ion battery to electric vehicles	CO 1	T1:3.14 , R1:24
7	Corrosion, causes and effects of corrosion, chemical corrosion	CO 1	T1:3.20, R1:1.2
8	Electrochemical corrosion, mechanism of electrochemical corrosion	CO 1	T1:3.21, R1:2.1
9	Cathodic protection, sacrificial anode and impressed current methods	CO 1	T1:3.22, R1:6.4
10	Metallic coatings, Galvanization and tinning, electroplating of Copper.	CO 1	T1:3.23, R1:6.3,6.6
11	Hardness of water, causes of hardness, disadvantages of hard water	CO 2	T1:2.1, R1:4
12	Types of hardness, temporary and permanent, expression and units of hardness	CO 2	T1:2.1, R1:5.3
13	Estimation of hardness of water by complexometric method	CO 3	T1:2.6, R1:6.1
14	potable water and its specifications, steps involved in the treatment of water, disinfection of water by chlorination and ozonization	CO 2	T1:2.6.5, R1:14
15	External treatment of water, ion-exchange process	CO 3	T1:2.8, R1:12.3
16	Desalination of water, reverse osmosis	CO 3	T1:2.10.2, R1:17.4
17	Classification of polymers; types of polymerization-addition, condensation polymerization with examples.	CO 4	T1: 3.5, R1: 3

S.No	Topics to be covered	CO's	Reference
18	Plastics, thermoplastic and thermosetting plastics	CO 4	T1:1.4, R1: 2.10
19	Preparation, properties and engineering applications of PVC	CO 3	T1:3.5, R1: 7.2
20	Preparation, properties and engineering applications of Nylon 6,6 s	CO 4	T1: 3.12, R1:7.7 5.1.2
21	Preparation, properties and engineering applications of Bakelite	CO 4	T1:3.14, R1: 3.2.3
22	Biodegradable polymers, polylactic acid and polyvinyl alcohol and their applications.	CO 4	T1:3.14, R1: 3.2.3
23	Elastomers, vulcanization of natural rubber	CO 4	T1: 3.15, R1:6.1
24	Preparation, properties and applications of Buna-s and Thiokol rubber.	CO 4	T1: 3.22, R1: 6.7
25	Classification of fuels, analysis of coal, proximate analysis of coal and their significance	CO 5	T1:4.2, R1: 2.1, 7.1,7.2
26	Ultimate analysis of coal and their significance	CO 4	T1:4.4.1, R1:7.1,7.2
27	Liquid fuels, petroleum and its refining	CO 5	T1:4.5.2, R1:15.2
28	Composition, characteristics and applications of natural gas, LPG and CNG	CO 5	T1:4.6, R1:9.1,9.2
29	Alternative and non-conventional sources of energy: solar, wind and hydropower advantages and disadvantages.	CO 4	T1:4.6, R1:9.8
30	Calorific value of fuel: HCV and LCV, Dulongs formula,	CO 5	T1:4.8, R1: 4.1
31	Calculation of air quantity required for complete combustion of fuel, numerical problems.	CO 5	T2:16.9 R1:8.11.2
32	Nanomaterials, preparation of nanoparticles by sol-gel method	CO 6	T1: 6.0, R1: 1
33	Preparation of nanoparticles by chemical reduction method and applications of nanomaterials.	CO 6	T1: 6.1, R1:11
34	Smart materials and their engineering applications, shape memory materials, Poly L-Lactic acid.	CO 6	T1: 6.1 R2:12.24
35	Thermoresponse materials, Polyacryl amides, Poly vinyl amides.	CO 6	T1: 6.1
36	Cement, composition of Portland cement	CO 6	T1: 5.1.2, R1: 3.2
37	Setting and hardening of cement.	CO 6	T1: 5.1.3, R1: 3.3
38	Lubricants, characteristics of a good lubricant	CO 6	T1: 3.24, R1: 3,5

S.No	Topics to be covered	CO's	Reference
39	Mechanism of lubrication, thick film, thin film and extreme pressure lubrication	CO 6	T1: 3.24, R1: 3,5
40	properties of lubricants, viscosity, flash and fire point, cloud and pour point	CO 6	T1: 3.25, R1: 7 R1: 7
PROBLEM SOLVING/ CASE STUDIES			
1	Problems on temporary and permanent hardness in Degree French and ppm	CO 3	T1:2.1, R1:5.4
2	Problems on temporary, permanent and total hardness in ppm and Degree Clark	CO 3	T1:2.1, R1:5.4
3	Problems on the temporary, permanent and total hardness of water in Degree French and Degree Clark.	CO 3	T1:2.1, R1:5.5
4	Problems on the temporary, permanent and total hardness of water in Degree Clark and Mg/L.	CO 3	T1:2.1, R1:5.5
5	Problems on the total hardness in terms of calcium carbonate equivalents by using EDTA method.	CO 3	T1:2.6, R1:6.2
6	Problems on the temporary hardness and permanent hardness in terms of calcium carbonate equivalents by using EDTA method.	CO 3	T1:2.6, R1:6.2
7	Problems on the temporary hardness in terms of calcium carbonate equivalents by using EDTA method.	CO 3	T1:2.6, R1:6.2
8	Problems on the permanent hardness in terms of calcium carbonate equivalents by using EDTA method.	CO 3	T1:2.6, R1:6.2
9	Problems on the higher and lower calorific values of the fuel.	CO5	T1:4.8, R1:4.3
10	Problems on the gross and net calorific values of the fuel.	CO 5	T1:4.8, R1:4.3
11	Problems on HCV and LCV (polar coordinates).	CO 5	T1:4.8, R1:4.3
12	Problems on GCV and NCV	CO 5	T1:4.8, R1:4.3
13	Problems on calculation of air quantity required for complete combustion of coal	CO 5	T1:4.9, R1:10.2
14	Problems on complete combustion of fuel in air	CO 5	T1:4.9, R1:10.2
15	Problems on calculation of air quantity required for complete combustion of fuel	CO 5	T1:4.9, R1:10.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Definitions & terminology discussion onbatteries chemistry and corrosion	CO 1	T1:6.1, R1: 7.4,1.2
2	Definitions & terminology discussion on water and its treatment	CO 2, CO3	T1:2.1, R1:5.3
3	Definitions &terminology discussion on polymer technology	CO 3, CO 4	T1: 3.5, R1: 7.2

S.No	Topics to be covered	CO’s	Reference
4	Definitions &terminology discussion on energy sources	CO 5	T1:4.2, R1:2.1
5	Definitions & terminology discussion on engineering materials	CO 6	T1: 6.0, R1: 11,3,3.2
DISCUSSION OF TUTORIAL QUESTION BANK			
1	Question bank discussion on batteries chemistry and corrosion	CO 1	T1:6.1, R1: 7.4,1.2
2	Question bank discussion on water and its treatment	CO 2, CO 3	T1:2.1, R1:5.3
3	Question bank discussion on polymer technology	CO 4	T1: 3.5, R1: 7.2
4	Question bank discussion on energy sources	CO 5	T1:4.2, R1:2.1
5	Question bank discussion on engineering materials	CO 6	T1: 6.0, R1: 11,3,3.2

24. PROGRAM OUTCOMES & PROGRAM SPECIFIC 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
Program Specific Outcomes	
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.

25. 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 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	Seminar / Conferences / Research papers

26. 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

27. 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	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-	-

28. 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 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
	PO 7	Use metallic coatings to control the corrosion in metals and know the impact in socio economic and environmental contexts for sustainable development..	2
CO 2	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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 3	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.	3
	PO 2	Identify the problem and formulate for finding the hardness of water in terms of CaCO3 equivalents with given information and data by applying principles of science..	2
CO 4	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
	PO 7	Use biodegradable polymers to reduce the soil pollution and know the impact in socio economic and environmental contexts for sustainable development..	2
CO 5	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.	3
	PO 2	Identify the problem and formulate for finding the hardness of water in terms of CaCO3 equivalents with given information and data by applying principles of science.. .	2
	PO 7	Use biodegradable polymers to reduce the soil pollution and know the impact in socio economic and environmental contexts for sustainable development.	2
CO 6	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
	PO 7	Use biodegradable polymers to reduce the soil pollution and know the impact in socio economic and environmental contexts for sustainable development.	2

29. 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	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	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 4	2	-	-	-	-	-	2	-	-	-	-	-	-	-	-
CO 5	3	2	-	-	-	-	2	-	-	-	-	-	-	-	-
CO 6	2	-	-	-	-	-	2	-	-	-	-	-	-	-	-

30. 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	-	-	-	-	-	66.6	-	-	-	-	-	-	-	-
CO 2	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.6	-	-	-	-	-	66.6	-	-	-	-	-	-	-	-
CO 5	100	20	-	-	-	-	66.6	-	-	-	-	-	-	-	-
CO 6	66.6	-	-	-	-	-	66.6	-	-	-	-	-	-	-	-

31. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

2 - $40\% < C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

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

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

32. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓				

33. ASSESSMENT METHODOLOGY INDIRECT:

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

34. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1	NO POVERTY	
2	ZERO HUNGER	
3	GOOD HEALTH AND WELL-BEING	Water purification can help to decrease dangerous bacteria and other chemicals that can weaken the immune system by removing pollutants and impurities. This may assist stay in good health and lowers chance of illness.
4	QUALITY EDUCATION	The fundamental principles of water treatment and its applications in industry, apply electrochemical principle in batteries
5	GENDER EQUALITY	

6	CLEAN WATER AND SANITATION	Safe and readily available water is important for public health, domestic use, food production or recreational purpose.countries' economic growth and can contribute greatly to poverty reduction.
7	AFFORDABLE AND CLEAN ENERGY	Affordable electricity is provided by clean energy sources such as solar, wind and hydropower.
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	Renewable energy systems for sustainable cities
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	Renewable energy systems for sustainable cities

13	CLIMATE ACTION	Non-renewable energy resources release harmful greenhouse gases into the atmosphere, creating the greenhouse effect which causes global warming.
14	LIFE BELOW WATER	
15	LIFE ON LAND	The biodegradable plastics material focuses on creating a more sustainable and greener world with a smaller environmental imprint.
16	PEACE, JUSTICE AND STRONG INSTITUTIONS	
17	PARTNERSHIPS FOR THE GOALS	

Approved by: Board of Studies in the meeting conducted on21-August-2023 .

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal- 500 043, Hyderabad, Telangana

APPLIED PHYSICS
COURSE TEMPLATE

1	Department	**MECHANICAL ENGINEERING**				
2	Course Title	**APPLIED PHYSICS**				
3	Course Code	AHSD07				
4	Class / Semester	II				
5	Regulation	BT-23				
6	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	-	3	-	-
7	Type of course (**Tick type of course**)	Core	Professional Elective	Open Elective	VAC	MOOCs
		-	-	-	-	-
8	Course Offered	Odd Semester ✗		Even Semester ✓		
9	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: 64		Tutorials: Nil		Practical: Nil	
10	Course Coordinator	Dr. K. Hari Prasad				
11	Date Approved by BOS	24 August 2023				
12	Course Webpage	https://www.iare.ac.in/sites/default/files/BT23/AHSD07.pdf				
13	Course Prerequistes	**Level UG/PG**	**Course Code**	**Course Title**	**Semester**	
		Intermediate	-	-	-	

14. Course Overview

The aim of this course is to promote understanding of fundamental knowledge in physics needed for the future technological advances. The concepts covered are in the fields of solid state physics, modern physics, superconductors and nanoscience. This knowledge helps to develop the ability to apply the principles in many advanced technological sectors such as nanotechnology, optical fiber communication, quantum technology etc.

15. Course Objectives:

The students will try to learn:

I	Fundamental concepts needed to explain a crystal structure in terms of atom positions, unit cells, and crystal symmetry.
II	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.
III	The metrics of optoelectronic components, lasers, optical fiber communication and be able to incorporate them into systems for optimal performance.
IV	The appropriate magnetic, superconducting and nanomaterials required for various engineering applications.

16. Course Outcomes:

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

S.No	Course outcome description
CO 1	Use the general rules of indexing of directions and planes in lattices to identify the crystal systems and the Bravais lattices.
CO 2	Extend the principles of dual nature of matter and Schrodinger wave equation to a particle enclosed in simple systems.
CO 3	Analyze the concepts of laser with normal light in terms of mechanism for applications in different fields and scientific practices.
CO 4	Comprehend the knowledge on functionality of components in optical fiber communication system by using the basics of signal propagation, attenuation and dispersion.
CO 5	Gain knowledge on properties of magnetic and superconducting materials suitable for engineering applications.
CO 6	Formulate the principle factors, fabrication, characterization techniques and the applications of nanomaterials.

17. Mapping of topic learning outcomes (TLO) to course outcomes

SNo	TOPIC(S)	TLO No	Topic Learning Outcome's	Course Outcome:	Blooms Level
1	Space lattice, Basis, unit cell, lattice parameters	TLO 1	Recollect the basic properties of crystallography and crystal structures.	CO 1	Remember
2	Crystal systems	TLO 2	Classify various crystal systems in terms of unit cell dimensions and crystallographic axes.	CO1	Understand
3	Bravais lattices	TLO 3	Draw the Bravais lattice structures formed in seven crystal systems.	CO1	Understand

SNo	TOPIC(S)	TLO No	Topic Learning Outcome's	Course Outcome:	Blooms Level
4	Simple cubic, Body centered cubic, Face centered cubic structures	TLO 4	Explain different crystal structures and determine their packing fractions.	CO1	Understand
5	Planes in a crystal	TLO 5	Identify different planes that can be formed in the crystal structure.	CO1	Apply
6	Interplanar distance	TLO 6	Determine the expression for interplanar spacing in orthogonal crystal system.	CO1	Apply
7	Waves and particles	TLO 7	Explainthe concept of dual nature of matter and light radiation.	CO2	Understand
8	de broglie hypothesis, Matter waves	TLO 8	Extend the debroglie hypothesis to the concept of matter waves.	CO2	Understand
9	Davisson and Germers experiment	TLO 9	Describe how Davisson and Germer experiment explained the existence of matter waves.	CO2	Understand
10	Schrodinger time independent wave equation	TLO 10	Discuss the Schrodinger time independent wave equation associated with matter waves.	CO2	Understand
11	Physical significance of wave function	TLO 11	Analyze the physical significance of wave function associated with matter waves.	CO2	Apply
12	Infinite square well potential	TLO 12	Apply Schrödinger's wave equation for energy values of a free particle confined in one dimensional potential square well.	CO2	Apply
13	Characteristics of lasers	TLO 14	Discuss the basic concepts of laser light sources.	CO3	Understand
14	Spontaneousand stimulated emission of radiation	TLO 15	Obtain the relation between Einstein coefficients associated with absorption, spontaneous emission and stimulated emission.	CO3	Apply
15	Lasing action	TLO 16	Explain the concepts involvedin producing lasing action.	CO3	Understand
16	Ruby and He-Ne lasers	TLO 17	Describe in detail the principle and working of Ruby and He-Ne lasers.	CO3	Understand
17	Applications of lasers	TLO 18	Identify the engineering applications of lasers in different fields.	CO3	Apply

SNo	TOPIC(S)	TLO No	Topic Learning Outcome's	Course Out-come:	Blooms Level
18	Principle and construction of an optical fiber	TLO 19	Illustrate the principle and construction of optical fibersused in communication system.	CO 4	Understand
19	Acceptance angle, Numerical Aperture	TLO 20	Derive the expressions for the acceptance angle and numerical aperture of an optical fiber.	CO 4	Understand
20	Types of optical fibers, Single mode, multimode, step index, graded index	TLO 21	Discuss different types of optical fibers based on refractive index profile and modes of propagation.	CO 4	Understand
21	Optical fiber communication system	TLO 22	Elucidate the block diagram of fiber optic communication system.	CO 4	Apply
22	Applications of optical fibers	TLO 23	Enlist the applications of optical fibers.	CO4	Remember
23	Permeability, field intensity, magnetic field induction, magnetization, magnetic susceptibility,	TLO 24	Acquire knowledge of basic terms related to magnetic materials.	CO 5	Understand
24	Origin of magnetic moment, Bohr magneton	TLO 25	Describe magnetic moment in an atom in termsof Bohr magneton.	CO 5	Understand
25	Classification of dia, para and ferro magnetic materials on the basis of magnetic moment	TLO 26	Classify different magnetic materials based on electron theory.	CO 5	Understand
26	Hysteresis curve	TLO 27	Examine the spontaneous magnetization in ferromagnets based on orientation of domains.	CO 5	Understand
27	Superconductivity, general properties	TLO 28	Recall he definition of superconductivity based on resistance.	CO 5	Remember
28	Meissner effect	TLO 30	Explain the Meissner effect related to superconductors.	CO 5	Understand

SNo	TOPIC(S)	TLO No	Topic Learning Outcome's	Course Out-come:	Blooms Level
29	Effect of magnetic field	TLO 31	Analyze the effect of magnetic field on superconductors.	CO 5	Apply
31	BCS theory	TLO 33	Elucidate the concept of flux quantization and BCS theory.	CO 5	Apply
32	Applications of superconductors	TLO 34	Discuss the applications of superconductors.	CO 5	Understand
33	Nanoscale	TLO 35	Recall the definition of nano scale and nanotechnology.	CO 6	Remember
34	Quantum confinement	TLO 36	Explain the quantum confinement factor of nanomaterials.	CO 6	Understand
35	Surface to volume ratio	TLO 37	How the surface to volume ratio changes when particle size is reduced to nano scale.	CO 6	Understand
36	Bottom-up fabrication: sol-gel, precipitation, combustion methods, top-down fabrication: ball milling, physical vapor deposition, chemical vapor deposition	TLO 38	Discuss different methods of preparation of nanomaterialssuch as sol-gel, precipitation, and combustion, ball milling, physical vapor deposition and chemical vapor deposition.	CO 6	Understand
37	Characterization techniques: x-ray diffraction, transmission electron microscopy	TLO 39	Acquire the knowledge of different characterization techniques such as X-ray diffraction, Scanning Electron Microscopy and Transmission Electron Microscopy.	CO 6	Understand
38	Applications of nanomaterials	TLO 40	Discuss the applications of nanomaterialsin different engineering fields.	CO 6	Understand

18. Employability Skills

Project based skills: Applied physics for engineering students develop experimental skills, mathematical and problem solving abilities, required to carry out research and development in a large number of specialties.

19. Content Delivery / Instructional Methologies:

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

20. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.
Semester End Examination (SEE): The SEE is conducted for 60 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. No choice is given from first two modules. Each question carries 12 marks. There could be a maximum of two sub divisions in a question.

Table 4: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

21. Course content - Number of modules: Five

MODULE I	**CRYSTAL STRUCTURES** | **Number of Lectures: 12**
	Introduction, space lattice, basis, unit cell, lattice parameter, Bravais lattices, crystal systems, structure and packing fractions of simple cubic, body centered cubic, face centered cubic crystals, directions and planes in crystals, Miller indices, separation between successive [h k l] planes.
MODULE II	**QUANTUM PHYSICS** | **Number of Lectures: 12**
	Waves and particles, de Broglie hypothesis, matter Waves, Davisson and Germer's experiment, Heisenberg's uncertainty principle, Schrödinger's time independent wave equation, physical significance of the wave function, infinite square well potential.

MODULE III	**LASERS AND FIBER OPTICS**	**|Number of Lectures: 15**
	Characteristics of lasers, spontaneous and stimulated emission of radiation, population inversion, lasing action, Ruby laser, He-Ne laser and applications of lasers. **P**rinciple 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	MAGNETIC AND SUPERCONDUCTING PROPERTIES	| Number of Lectures: 12
	Permeability, field intensity, magnetic field induction, magnetization, magnetic susceptibility, origin of magnetic moment, Bohr magneton, classification of dia, para and ferro magnetic materials on the basis of magnetic moment. Superconductivity, general properties, Meissner effect, effect of magnetic field, type-I & type-II superconductors, BCS theory, applications of superconductors.	
MODULE V	NANOTECHNOLOGY	| Number of Lectures: 13
	Nanoscale, quantum confinement, surface to volume ratio, bottom-up fabrication: sol-gel, precipitation, combustion methods, top-down fabrication: ball milling, physical vapor deposition, chemical vapor deposition, characterization techniques: x-ray diffraction, transmission emission microscopy, applications of nanomaterials.	

TEXTBOOKS

1. Arthur Beiser, Shobhit Mahajan and Rai Choudhary, *Concepts of Modern Physics,* , Tata McGraw Hill, 7th Edition, 2017.

REFERENCE BOOKS:

1. H J Callister, *A Textbook of Materials Science and Engineering,* , Wiley Eastern Edition, 8th Edition, 2013.
2. Halliday, Resnick and Walker, *Fundamentals of Physics,* , John Wiley Sons,11th Edition, 2018.
3. Charles Kittel, *Introduction to Solid State Physics,* , Wiley Eastern, 2019.
4. S.L. Gupta and V. Kumar, *Elementary Solid State Physics,* ,Pragathi Prakashan, 2019.
5. K K Chattopadhyay and A N Banerjee, *Introduction to Nanoscience and Nanotechnology,* , Prentice Hall India, 2nd Edition, 2011.

Electronic Resources:

1. NPTEL :: Physics - NOC:Quantum Mechanics I
2. NPTEL :: Physics - NOC:Introduction to Solid State Physics
3. NPTEL :: Physics - NOC:Solid State Physics
4. https://nptel.ac.in/courses/104104085
5. NPTEL :: Metallurgy and Material Science - NOC:Nanotechnology, Science and Applications

Material Online:

1. Course template
2. Tutorial question bank
3. Definition and terminology
4. Tech-talk topics
5. Assignments
6. Model question paper - I
7. Model question paper - II
8. Lecture notes
9. Early learning readiness videos (ELRV)
10. Power point presentations

22. COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
Discussion on OBE			
1	Discussion on Outcome Based Education, CO, POs and PSOs		
Content Delivery (Theory)			
1	Introduction, space lattice	CO 1	T1; R1
2	Basis, unit cell, lattice parameter	CO 1	T1; R1
3	Crystal systems	CO 1	T1; R1
4	Bravais lattices	CO 1	T1; R1
5	Simple cubic structure	CO 1	T1; R1
6	Body centered cubic structure	CO 1	T1; R1
7	Face centered cubic structure	CO 1	T1; R1
8	Directions and planes in crystals	CO 1	T1; R1
9	Miller indices	CO 1	T1; R1
10	Separation between successive [h k l] planes	CO 1	T1; R1
11	Introduction to Quantum Physics	CO 2	T1; R1, R2
12	Wave-particle duality of radiation	CO 2	T1; R1, R2
13	de broglie hypothesis and de broglie wavelength	CO 2	T1; R1, R2
14	Properties of Matter waves	CO 2	T1; R1, R2
15	Davisson and Germer's experiment	CO 2	T1; R1, R2
16	Schr¨odinger time independent wave equation	CO 2	T1; R1, R2
17	Physical significance of wavefunction	CO 2	T1; R1, R2
18	Particle in a one-dimensional potential box	CO 2	T1; R1, R2
19	Characteristics of laser, Spontaneous and Stimulated emis sion	CO 3	T1; R3, R4
20	Metastable state, Population inversion, Lasing action	CO 3	T1; R3, R4
21	Ruby laser	CO 3	T1; R3, R4

S.No	Topics to be covered	CO's	Reference
22	He-Ne laser, Applications of LASER	CO 3	T1; R3, R4
23	Principle and construction of optical fibers	CO 4	T1; R3, R4
24	Acceptance angle, Acceptance cone, Numerical Aperture	CO 4	T1; R3, R4
25	Types of optical fibers	CO 4	T1; R3, R4
26	Optical fiber communication system, Applications of optical fibers	CO 4	T1; R1, R2
27	Permeability, field intensity, magnetic field induction, magnetization, magnetic susceptibility	CO 5	T1; R1
28	origin of magnetic moment, Bohr magneton	CO 5	T1; R1
29	Diamagnetic and Paramagnetic materials	CO 5	T1; R1
30	Ferromagnetic materials	CO 5	T1; R1
31	Hysteresis curve	CO 5	T1; R1
32	Superconductivity, general properties	CO 5	T1; R1
33	Meissner effect, effect of magnetic field	CO 5	T1; R1
34	type-I & type-II superconductors	CO 5	T1; R1
35	BCS theory	CO 5	T1; R1
36	applications of superconductors	CO 5	T1; R1
37	Nanoscale, quantum confinement, surface to volume ratio	CO 6	T1; R4
38	bottom-up fabrication: sol-gel, precipitation, combustion methods	CO 6	T1; R4
39	top-down fabrication: ball milling, physical vapor deposition, chemical vapor deposition	CO 6	T1; R4
40	characterization techniques: x-ray diffraction, transmission electron microscopy, applications of nanomaterials	CO 6	T1; R4
Problem Solving/Case Studies			
1	Packing fraction	CO 1	T1; R1
2	Miller indices	CO 2	T1; R1
3	Interplanar spacing	CO 2	T1; R1
4	de broglie wavelength	CO 2	T1; R1, R2
5	Energies associated with one dimensional potential box	CO 2	T1; R1, R2
6	Wavelength and Energy bandgap, Divergence	CO 3	T1; R3, R4
7	Relative population of two states, Number of photons emitted	CO 3	T1; R3, R4
8	Acceptance angle and Numerical Aperture	CO 4	T1; R1
9	Magnetic moment, Magnetic induction, Permeability	CO 5	T1; R1
10	Intensity of magnetization, Magnetic susceptibility	CO 5	T1; R1
11	Critical temperature	CO 5	T1; R4
12	Critical field	CO 5	T1; R4
13	Surface to volume ration	CO 6	T1; R4
14	Particle size	CO 6	T1; R4
15	Debye Scherrer method	CO 6	T1; R4

S.No	Topics to be covered	CO's	Reference
Definition and Terminology			
1	Crystal structures	CO 1	T1; R1
2	Quantum physics	CO 2	T1; R1, R2
3	Lasers and fiber Optics	CO 3	T1; R3, R4
4	Magnetic and superconducting properties	CO 4	T1; R1
5	Nanotechnology	CO 5	T1; R4
Tutorial Question Bank			
1	Crystal structures	CO 1	T1; R1
2	Quantum physics	CO 2	T1; R1, R2
3	Lasers and fiber Optics	CO 3	T1; R3, R4
4	Magnetic and superconducting Properties	CO 4	T1; R1
5	Nanotechnology	CO 5	T1; R4

23. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

Program Outcomes

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

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

24. HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

25. 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

26. 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	✓	✓	-	-		-	-	-	-	-	-	-	-	-	-

27. 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	**Illustrate** the different crystal structures based on arrangement of atoms in a unit cell, calculate their packing fraction and use those expressions to integrate with other engineering disciplines.	3
	PO 2	**Explain** the given **problem statement** and formulate lattice parameters and miller indices of a crystal from the provided **information** and **data** in reaching substantial conclusions by the **interpretation of packing fraction.**	4

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 2	PO 1	**Outline** drawbacks of classical mechanics, basic principles **dual nature** of matter wave, **derive** mathematical wave equation of matter waves and come to **conclusion** of quantization of energy used in quantum dots.	3
	PO 2	**Explain** the given **problem statement** and formulate quantum confinement problems related to particle enclosed in small dimension from the provided **information** and **data** in reaching substantial conclusions by the **interpretation of result**s.	4
	PO 4	**Identify** the use of these 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 principle** for applications in different fields and scientific practices.	3
	PO 2	**Explain** different components involved in **laser system** by using the **basics** of absorption, emission and amplification of light radiation.	4
CO 4	PO 1	**Gather** the knowledge on functionality of components in optical fiber communication system by using the basics of signal propagation, attenuation and dispersion.	3
	PO 2	**Explain** functionality of components in optical fiber communication **system** by using the **basics** of signal propagation, attenuation and dispersion.	4
	PO 4	**Identify the given problem** and **formulate** expressions for acceptance angle and numerical aperture with the given **information** and **data** by applying principles of information of propagation through optical waveguides.	2
CO 5	PO 1	**Utilize** spin and orbital motion of electrons in determining **magnetic moment** of materials in terms of Bohr magneton materials having specific **engineering applications**.	3
CO 6	PO 1	**Illustrate** the different principal factors affecting particle size, calculate their surface to volume ratio and use those expressions to integrate with other engineering disciplines.	3
	PO 2	**Explain** the given **problem statement** and formulate fabrication, characterization of nanomaterials provided **information** and **data** in reaching substantial conclusions by the **interpretation of application in different fields.**	4

28. 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	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	4	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	4	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-

29. 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	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	40	-	20	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	40	-	20	-	-	-	-	-	-	-	-	-	-	-
CO 5	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-

30. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

2 - 40 % $<C<$ 60% –Moderate

1-5 $<C \leq$ 40% – Low/ Slight

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

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

31. ASSESSMENT METHODOLOGY DIRECT:

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

32. ASSESSMENT METHODOLOGY INDIRECT:

-	Assessment of mini Projects by Experts	✓	End Semester OBE Feedback

33. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1	NO POVERTY	
2	ZERO HUNGER	
3	GOOD HEALTH AND WELL-BEING	
4	QUALITY EDUCATION	Graduates who have specialized in physics provide a unique component of the technical workforce. They are able to attack a wide variety of problems with their problem-solving skills and grasp of the principles of physics,. A well-trained physicist is capable of moving quickly among different technical areas, particularly into areas so new that they have not yet evolved into an engineering discipline.
5	GENDER EQUALITY	

6	CLEAN WATER AND SANITATION	
7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	
13	CLIMATE ACTION	

14	LIFE BELOW WATER	
15	LIFE ON LAND	
16	PEACE, JUSTICE AND STRONG INSTITUTIONS	
17	PARTNERSHIPS FOR THE GOALS	

Approved by: Board of Studies in the meeting conducted on 24 August 2023 .

Signature of Course Coordinator **HOD, ME**
Dr. K. Hari Prasad, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**MECHANICAL ENGINEERING**				
2	Course Title	**DIFFERENTIAL EQUATIONS AND VECTOR CALCULUS**				
3	Course Code	AHSD08				
4	Program	B.Tech				
5	Class/Semester	II				
6	Regulation	BT-23				
7	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	1	4	-	-
8	Type of course (**Tick type of course**)	Core $\checkmark$	Professional Elective $\times$	Open Elective $\times$	VAC $\times$	MOOCs $\times$
9	Course Offered	Odd Semester $\times$		Even Semester $\checkmark$		
10	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: 48 hours		Tutorials: 16 hours		Practical: 0 hours	
11	Course Coordinator	Ms.Praveena Rao				
12	Date Approved by BOS	23/08/2023				
13	Course Webpage	www.iare.ac.in/—-/—-				
14	Course Prerequisites	**Level**	**Course Code**	**Semester**	**Prerequisites**	
		B.Tech	AHSD02	I	Matrices and Calculus	

15. Course Overview

This course serves as a foundation course on differential equations and vector calculus. It includes techniques for solving ordinary differential equations, partial differential equations, vector differentiation and vector integration. It is designed to extract the mathematical developments, skills, from basic concepts to advance level of engineering problems to meet the technological challenges.

16. COURSE OBJECTIVES:

The students will try to learn:

I	The analytical methods for solving first and higher order differential equations with constant coefficients.
II	The analytical methods for formation and solving partial differential equations.
III	The physical quantities of vector valued functions involved in engineering field.
IV	The logic of vector theorems for finding line, surface and volume integrals.

17. COURSE OUTCOMES:

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

CO 1	Utilize the methods of differential equations for solving the orthogonal trajectories and Newton's law of cooling
CO 2	Solve the higher order linear differential equations with constant coefficients by using method of variation of parameters.
CO 3	Make use of analytical methods for PDE formation to solve boundary value problems.
CO 4	Identify various techniques of Lagrange's method for solving linear partial differential equations which occur in Science and engineering.
CO 5	Interpret the vector differential operators and their relationships for solving engineering problems.
CO 6	Apply the integral transformations to surface, volume and line of different geometrical models .

18. Topic Learning Outcome (TLOs):

S No	**TOPIC NAME**	**TLO No**	**Topic Learning Outcome's**	**Course Outcome**	Blooms Level
1	Fundamentals of ordinary differential equation	TLO 1	**Summarize** basic fundamentals of ordinary differential equations through a procedural approach.	CO 1	Understand
2	Differential equations of first order	TLO 2	**Identify** the method of variables separable to obtain the solution for ordinary differential equations.	CO 1	Apply
		TLO 3	**Use** the standard methods to solve homogeneous equations.	CO 1	Apply
		TLO 4	**Solve** the ordinary differential equations by converting the non-homogenous equations to homogenous form which is used to get the solution.	CO 1	Apply

S No	TOPIC NAME	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
3	Exact and non-Exact differential equations	TLO 5	**Distinguish** in between non-exact and exact equations with suitable examples	CO 1	Apply
		TLO 6	**Determine** the solution for non-exact equations based on set of ordinary differential equations.	CO 1	Understand
4	Applications of ODE	TLO 7	**Apply** standard methods for finding Orthogonal Trajectories of a family of curves.	CO 1	Apply
		TLO 8	**Determine** temperature of body at any time using Newton's law of cooling.	CO 1	Apply
5	Higher order linear differential equations	TLO 9	**Solve** higher order linear differential equations with constant coefficients to obtain the solution	CO 2	Apply
		TLO 10	**Utilize** the method of variation parameters to obtain the solution of higher order differential equations .	CO 2	Apply
6	Formation of partial differential equation	TLO 11	**Interpret** the partial differential equations by eliminating arbitrary constants.	CO 3	Understand
		TLO 12	**Formulate** the partial differential equations by eliminating arbitrary functions.	CO 3	Understand
7	Method of grouping and multipliers	TLO 13	**Utilize** the method of grouping to solve the Lagrange's linear equations.	CO 4	Apply
		TLO 14	**Use** the method of multipliers to obtain the solution of Lagrange's linear equations.	CO4	Apply
		TLO 15	**Solve** linear partial differential equation by using analytical methods.	CO 4	Apply
8	Fundamentals of vector functions	TLO 16	**Review** the vector properties on vector and scalar point functions which are used to find gradient ,divergence and curl	CO 5	Understand
		TLO 17	**Determine** directional derivative of vector point function to find its rate of change in given direction	CO 5	Understand

S No	TOPIC NAME	TLO No	Topic Learning Outcome's	Course Outcome	Blooms Level
9	Solenoidal and irrotational vectors	TLO 18	**Interpret** the vector properties to test whether the vector functions are solenoidal or irrotational	CO 5	Understand
10	Line, surface and volume integrals	TLO 19	**Determine** areas and volumes of functions by using line, surface and volume integrals.	CO 6	Understand
11	Integral theorems	TLO 20	**Determine** the areas of functions by using Green's theorem with suitable examples.	CO 6	Apply
		TLO 21	**Identify** the relation between surface integral and volume integral to find the volumes by using Stoke's theorem and Gauss-divergence theorem.	CO 6	Apply

19. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
Differential Equations: Employability/ Skill development: Uses the basic of differential equation calculation concept in the field of engineering.
Vector Calculus: Employability/ Skill development: Uses the concept of definite integral in engineering problems

20. Content Delivery / Instructional Methodologies:

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

21. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Semester End Examination (SEE): The SEE is conducted for 60 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. No choice is given from first two modules. Each question carries 12 marks. There could be a maximum of two sub divisions in a question

Table 4: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	40 Marks
Total	-	-	**100 Marks**	

22. Course content - Number of modules: Five:

MODULE I	**First order and first degree ordinary differential equations | Number of Lectures: 10**
	Exact differential equations, Equations reducible to exact differential equations, linear and Bernoulli's equations,. Applications: Orthogonal Trajectories (Cartesian Coordinates) Newton's law of cooling.
MODULE II	**Ordinary differential equations of higher order | Number of Lectures: 10**
	Second order linear differential equations with constant coefficients: non-homogeneous terms of the type e^{ax},sin ax,cosax, polynomials in x,$e^{ax}V(x)$ and method of variation of parameters.
MODULE III	**Partial differential equations |Number of Lectures: 09**
	Formation of partial differential equations by elimination of arbitrary constants and arbitrary functions, solutions of first order linear equations.
MODULE IV	**Vector differentiation | Number of Lectures: 09**
	Scalar and vector point functions; definitions of gradient, divergent and curl with examples; solenoidal and irrotational vector point functions; scalar potential function.
MODULE V	**Vector integration | Number of Lectures: 10**
	Line integral, surface integral and volume integral, Green's theorem in a plane, Stoke's theorem and Gauss divergence theorem without proofs.

TEXTBOOKS

1. B.S. Grewal "*Higher Engineering Mathematics*", Khanna Publishers, 44th Edition, 2017.
2. Erwin Kreyszig "*Advanced Engineering Mathematics*",10/e, John Wiley& Sons, 2011.

REFERENCE BOOKS:

1. R. K. Jain and S. R. K. Iyengar , "*, Advanced Engineering Mathematics*", 5th Edition, TMH, 2017.
2. George B. Thomas, Maurice D. Weir and Joel Hass, Thomas, "*Calculus*", 13/e, Pearson Publishers, 2013.
3. N.P.Bali and Manish Goyal"*A textbook of Engineering Mathematics*",Laxmi Publications, Reprint,2008

4. Dean G. Duffy, "*Advanced Engineering Mathematics with MATLAB*",CRC Press

5. Peter O'Neil, "*Advanced Engineering Mathematics*", Cengage Learning.

6. B.V. Ramana, "*Higher Engineering Mathematics*", McGraw Hill Education.

ELECTRONIC RESOURCES:

1. Engineering Mathematics - I, By Prof. Jitendra Kumar — IIT Kharagpur https://onlinecourses.nptel.ac.in/noc23_ma88/preview

2. Advanced Calculus for Engineers, By Prof. Jitendra Kumar, Prof. Somesh Kumar — IIT Kharagpur https://onlinecourses.nptel.ac.in/noc23_ma86/preview

3. http://www.efunda.com/math/math_home/math.cfm

4. http://www.ocw.mit.edu/resourcs/Mathematics

5. http://www.sosmath.com

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

23. COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
	Discussion on OBE		
1	**Discussion on Outcome Based Education, CO, POs and PSOs**		
	CONTENT DELIVERY (THEORY)		
1	Introduction to ordinary Differential equations	CO 1	T1:11.1,11.2 R3:11.1,11.2
2	Variable Separable,homogeneous differential equations and non-homogeneous differential equations .	CO 1	T1:11.4,11.5 R3:11.4,11.5
3	Exact differential equations	CO 1	T1:11.7,11.8 R3:11.6,11.7
4	Non-exact differential equations using integrating factors	CO 1	T1:11.9 R3:11.8
5	Linear differential equations of first order	CO 1	T1:11.10 R3:11.9
6	Bernoulli's Equation	CO 1	T1:11.11 R3:11.10
7	Reducible to linear equation by substitution	CO 1	T1:11.12 R3:11.12
8	Applications of ODE, Orthogonal trajectories	CO 1	T1:12.3 R3:12.3,12.4
9	Applications of ODE, Newton's law of cooling	CO 1	T1:12.6 R3:12.9

S.No	Topics to be covered	CO's	Reference
10	Linear Differential Equations of Second and Higher Order with Constant Coefficients	CO 2	T2:2.8 R6:2.5
11	Non-Homogeneous term of the type f (X) = e^{ax}	CO 2	T2:2.8 R6:2.5
12	Non-Homogeneous term of the type f (X) = Sinax	CO 2	T2:7.4 R3:7.1
13	Non-Homogeneous term of the type f (X) = Cosax	CO 2	T2:7.4 R3:7.1
14	Non-Homogeneous term of the type f (X) = X^n.	CO 2	T2:7.4 R3:7.1
15	Determine particular non-homogeneous term of the type f (X) = e^{ax} V(x)	CO 2	T2:7.4 R3:7.1
16	Solving second order linear differential equations using method of variation of parameters.	CO 2	T2:2.1 R6:2.9
17	Introduction to Partial differential equations	CO 3	T1:17.1 R3:16.1
18	Elimination of arbitrary constants (Formation of PDE)	CO 3	T1:17.1,17.2 R3:16.1,16.2
19	Elimination of arbitrary functions (Formation of PDE)	CO 3	T1:17.2 R3:16.2
20	Lagrange's Linear equation- Method of grouping	CO 4	T1:17.5,17.6 R3:16.3.1
21	Lagrange's Linear Equation -Method of Multipliers	CO 4	T1:17.5,17.6 R3:16.4- 16.5
22	Linear Partial differential equation of first order	CO 4	T1:17.5- 17.6 R3:16.5- 16.6
23	Solution of linear partial differential equation	CO 4	T1:17.5- 17.6 R3:16.5- 16.6
24	In Scalar and Vector Point Function(Definitions of Gradient, divergent, curl	CO 5	T1: 8.4 R6:8.1
25	Problems on directional derivative	CO5	T1:8.5 R6:11.3
26	Problems on Gradient of vector point functions	CO 5	T1:8.5 R6:11.3
27	Problems on divergence of vector point functions.	CO 5	T1:8.6 R6:11.4
28	Problems on curl of vector point function	CO 5	T1:8.6 R6:11.4
29	Properties of divergence and curl	CO 5	T1: 8.6 R6:11.7
30	Solenoidal and irrotational vectors	CO 5	T1: 8.6 R6:11.7
31	Introduction to Line integral	CO 6	T1: 8.11 R6:12.2

S.No	Topics to be covered	CO's	Reference
32	Problems on line integral	CO 6	T1: 8.28 R6:12.9
33	Introduction to surface integral	CO 6	T1: 8.12 R6:12.3
34	Problems on surface integral	CO 6	T1: 8.31 R6:12.26
35	Calculating areas by using Green's theorem	CO 6	T1: 8.13.4 R6:12.40
36	Stoke's theorem	CO 6	T1: 8.14 R6:12.6
37	Problems on Stoke's theorem	CO 6	T1: 8.36 R6:12.53
38	Volume integral	CO6	T1:8.15 R6:12.4
39	Gauss divergence theorem	CO 6	T1: 8.16 R6:12.7
40	Calculate the volumes by using Gauss divergence theorem	CO 6	T1: 8.42 R6:12.68
PROBLEM SOLVING/ CASE STUDIES			
1	Solving first order differential equations by using standard methods	CO 1	T1:21.1,21.4 R1:5.1
2	Applications of ODE: Orthogonal trajectories and Newton's law of cooling	CO 1	T1:21.13 R1:5.1,5.3
3	Solving Second order and higher order differential equations with constant coefficients	CO 2	T1:21.14 R1:5.5
4	Solving Second order and higher order differential equations by method of variation of parameters	CO 2	T1:22.3 R1:10.8
5	Solving problems on formation of partial differential equations by elimination of arbitrary constants	CO 3	T1:22.4 R1:10.9
6	Solving problems on formation of partial differential equations by elimination of arbitrary functions	CO 3	T2:10.1 R1:16.1
7	Solving linear Lagrange's equation by using grouping method	CO 4	T2:10.1 R1:16.2
8	Solving linear Lagrange's equation by using multipliers method	CO 4	T2:10.1 R1:16.2
9	Solving problems on Gradient and divergence	CO 5	T2:11.3 R1:16.5
10	Solving problems on Divergence and curl of a vector point functions	CO 5	T2: 11.3 R1:16.11
11	Solving problems on scalar potential function.	CO 5	T2: 11.3 R1:16.11

S.No	Topics to be covered	CO's	Reference
12	Solving problems on vector point functions: Solenoidal and irrotational.	CO 5	T2: 11.3 R1:16.9
13	Solving problems on Green's theorem	CO 6	T2: 11.4 R1:16.18
14	Solving problems on Stokes theorem	CO 6	T1:17.1- 17.2 R1:16.1- 16.2
15	Solving problems on Gauss divergence theorem	CO 6	T1:17.1- 17.2 R1:16.1- 16.2
DEFINITION AND TERMINOLOGY			
1	Definitions and terminology on ordinary differential equations	CO 1	T1:21.1,21.4 R1:5.1
2	Definitions and terminology on higher order differential equations	CO 2	T1:22.1-22.2 R1:10.8
3	Definitions and terminology on partial differential equations	CO 3 CO 4	T2:15.5 R1:7.5
4	Definitions and terminology on vector differentiation	CO 5	T2:10.3 R1:16.4
5	Definitions and terminology on vector integration	CO 6	T1:17.1- 17.2 R1:16.1-16.2
QUESTION BANK			
1	Discussion of first order differential equations	CO 1	T1:21.1,21.4 R1:5.1
2	Discussion of second and higher order differential equations	CO 2	T1:22.1- 22.2 R1:10.8
3	Discussion of partial differential equations	CO 3 CO 4	T2:15.5 R1:7.5
4	Discussion of vector differentiation	CO 5	T2:10.3 R1:16.4
5	Discussion of vector integration	CO 6	T1:17.1- 17.2 R1:16.1- 16.2

24. PROGRAM OUTCOMES & PROGRAM SPECIFIC 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
Program Specific Outcomes	
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.

25. 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

26. 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	CIE/Quiz/AAT
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	2	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

27. 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	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-

28. 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	Determine the solution of complex engineering problems modelled by first order linear differential equations by using standard methods of Principles of Mathematics	2
	PO 2	Model the problems with help of ordinary differential equations, formulation of statement Newton's law of cooling apply the basic principle of mathematics and solve complex engineering problems by interpretation of results	6
	PSO 1	Implement ordinary differential equations for applications in solid and fluid mechanics, hydrodynamic problems, mechanical vibrations and analyzing mechanical systems.	1
CO 2	PO 1	Determine the solution of complex engineering problems modelled by Second and higher order linear differential equations with constant coefficients by using Principle of mathematics, substitution method and method of variation of parameter	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
	PSO 1	Apply higher order differential equations for design of complex problems in solid and fluid mechanics, hydrodynamic problems, structural vibrations and mechanical systems.	1

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 3	PO 2	Make use of the different methods in the 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
	PSO 2	Implement Partial Differential Equations for structural design and solving complex analysis problems of thermo-fluid systems.	1
CO 4	PO 1	Solve Lagrange's linear equation related to complex engineering problems such as grouping and multiplier method using principle of mathematics for solving linear partial differential equations which occur in Science and engineering .	2
CO 5	PO 2	Interpret the statement and formulation by differential calculus of complex engineering problems which transforms vector functions, gradients. Divergence, curl, using principle of mathematics to different bounded regions in calculating areas. by interpretation of results.	6
CO 6	PO 1	Apply the mathematics, science and Engineering fundamentals to dynamic equilibrium the problems for analysis of forces using the knowledge of mathematics and science fundamentals.	2

29. 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	-	-
CO 2	2	6	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 3	-	6	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-

30. 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	-	-	-	-	-	-	-	-	-	-	16.67	-	-
CO 2	66.7	60	-	-	-	-	-	-	-	-	-	-	16.67	-	-
CO 3	-	60	-	-	-	-	-	-	-	-	-	-	-	50	-
CO 4	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	60	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-

31. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

2 - 40 % <C < 60% –Moderate

1-5 <C$\leq$ 40% – Low/ Slight

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

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

32. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓				

33. ASSESSMENT METHODOLOGY INDIRECT:

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

34. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs. Mathematics plays an important role in the achievement of the Sustainable Development Goals (SDG) and at the same time these allow working with real situations in the subject of mathematics, providing the student with active learning. Sustainability is used to make the student see the usefulness of mathematics while instilling values and attitudes towards it.

x	1	NO POVERTY	
x	2	ZERO HUNGER	
x	3	GOOD HEALTH AND WELL-BEING	
✓	4	QUALITY EDUCATION	**Quality Education:**This subject will improve the quality education in engineering and provides the knowledge in mathematical modelling which is used for real time applications
x	5	GENDER EQUALITY	
x	6	CLEAN WATER AND SANITATION	

x	7	AFFORDABLE AND CLEAN ENERGY	
x	8	DECENT WORK AND ECONOMIC GROWTH	
x	9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	
x	10	REDUCED INEQUALITIES	
x	11	SUSTAINABLE CITIES AND COMMUNITIES	
x	12	RESPONSIBLE CONSUMPTION AND PRODUCTION	
x	13	CLIMATE ACTION	

x	14		
x	15		
x	16		
x	17		

Approved by: Board of Studies in the meeting conducted on 23/08/2023

Signature of Course Coordinator **HOD, CE**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

PROFESSIONAL COMMUNICATION COURSE TEMPLATE

1	Department	**MECHANICAL ENGINEERING**				
2	Course Title	**ENGINEERING MECHANICS**				
3	Course Code	AMED04				
4	Program	B.Tech				
5	Semester	II Semester				
6	Regulation	BT-23				
7	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	0	3	-	-
8	Type of course (**Tick type of course**)	Core	Professional Elective	Open Elective	VAC	MOOCs
		✓	-	-	-	-
9	Course Offered	Odd Semester ✗		Even Semester ✓		
10	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: .... hours		Tutorials: .... hours		Practical: .... hours	
11	Course Coordinator	Dr. B D Y Sunil				
12	Date Approved by BOS					
13	Course Webpage	www.iare.ac.in				
14	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**	
		B.Tech	AMED02	I	Matrices and Calculus	

15. Course Overview

Engineering Mechanics is a branch of science that deals with the forces that act on bodies which is at rest or in motion. It is based on physics, mathematics and principles of static and dynamic equilibrium of rigid bodies. This course is the foundation of all the mechanical sciences, such as civil engineering, Mechanical engineering and aeronautical engineering.

16. Employability Skills

1. Employment advantage: This can give competitive advantage when seeking employment to solve statically determined force systems under equilibrium conditions.
2. Problem-Solving and Analytical Thinking: Engineering Mechanics involves in analysing complex physical systems and devising solutions to the structural problems. This cultivates the ability to think critically and find innovative solutions, which is a fundamental skill sought by employers in various industries.

3. Safety Awareness: Understanding the principles of forces, motion, and equilibrium enhances safety consciousness. Graduates can apply this awareness to workplaces where safety is a priority.

17. Relevance to Sustainability goals

1	NO POVERTY	
2	ZERO HUNGER	
3	GOOD HEALTH AND WELL-BEING	
4	QUALITY EDUCATION	Quality Education: An Engineering Mechanics course provides students with a strong foundation in science, mathematics, and problem-solving skills, enhancing their overall educational experience and empowering them to address real-world challenges.
5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	
7	AFFORDABLE AND CLEAN ENERGY	

8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	Industry, Innovation, and Infrastructure: Understanding Engineering Mechanics principles is crucial for developing and maintaining sustainable infrastructure and technological innovations. Students equipped with these skills can contribute to designing safer, more durable, and environmentally friendly infrastructure projects.
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	Sustainable Cities and Communities: Engineering Mechanics underpins the construction and maintenance of urban infrastructure. Students learn to design structures that can withstand environmental challenges and contribute to the safety and sustainability of urban spaces.
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	
13	CLIMATE ACTION	
14	LIFE BELOW WATER	
15	LIFE ON LAND	

16		
17		

18. Content Delivery / Instructional Methologies:

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

19. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Table 2: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

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 12 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
35%	Understand
55%	Apply

20. 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.
II	The effects of force and motion while carrying out the innovative design functions of engineering.

21. COURSE OUTCOMES:

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

CO1	**Determine** the unknown forces by free body diagrams to a given equilibrium force system through laws of mechanics.	Apply
CO2	**Calculate** the system of forces acting on wedge and screw jack by using the laws of static and dynamic frictions.	Apply
CO3	**Use** the concepts of centroid in stability problems for evaluation of area moment of inertia.	Apply
CO4	**Identify** the mass moment of inertia of symmetrical and non-symmetrical section using the concepts of centre of gravity.	Understand
CO5	**Solve** the position, velocity, acceleration and the characteristics of a body in dynamic equilibrium for various types of motion using appropriate mathematical tools.	Apply
CO6	**Develop** the governing equation from first principles by using work - energy and impulse - momentum in dynamic equilibrium condition.	Analyze

22. Topic Learning Outcome (TLOs):

TLO No	Topic Learning Outcome's	Course Outcome:	Blooms Level
1	Illustrate the basic approaches of mechanics referring to the coplanar, concurrent and parallel system of forces.	CO1	Understand
2	Analyze the laws of forces on rigid bodies under various constraints for the state of equilibrium.	CO1	Analyze
3	Determine resultant of parallel forces subjected to a moment of couple on the rigid bodies.	CO1	Apply

TLO No	Topic Learning Outcome's	Course Outcome:	Blooms Level
4	Compute the relative magnitude and direction of unknown force using free body diagrams for a specified equilibrium condition.	CO1	Apply
5	Outline the structural laws of friction on a body experiencing static, sliding or rolling friction.	CO2	Understand
6	Compute the frictional forces acting on wedge by using the laws of static friction.	CO2	Apply
7	Interpret the involvement of frictional force in screw jack for the conditions of self-locking and overhauling.	CO2	Understand
8	Determine the centroid for a given plane of regular and irregular sections from first principles.	CO3	Apply
9	Compute the centre of gravity of regular and composite volumes from first principles.	CO3	Apply
10	Apply Pappus and Guldinus theorems for centroid and centre of gravity on the lines and surfaces.	CO3	Apply
11	Understand the technical importance of second moment of area for regular and irregular bodies in improving structural strength.	CO3	Understand
12	Determine the area moment of inertia of composite sections using parallel and perpendicular axis theorems.	CO3	Apply
13	Calculate the radius of gyration of regular and composite geometries using the mass moment of inertia.	CO4	Apply
14	Deduce mass moment of inertia from first principles for solid circular disc, ring and cone.	CO4	Analyze
15	Compute mass moment of inertia at a given axis using transfer formula for composite bodies.	CO4	Apply
16	Apply the laws of motion to determine the characteristics of the body in motion like displacement, velocity and acceleration vectors.	CO5	Apply
17	Infer laws of motion to dynamic bodies using a rectangular path and polar coordinates.	CO5	Apply
18	Understand the interrelationship between impulse and momentum for bodies under impact through conservation of momentum.	CO5	Understand
19	Determine the impact and impulsive forces occurring in the system of bodies in collision using coefficient of restitution.	CO5	Apply
20	Discuss the nature of relation between force and mass under the influence of time for the bodies in acceleration.	CO6	Understand

TLO No	Topic Learning Outcome's	Course Outcome:	Blooms Level
21	Apply D'Alembert's principle on bodies under dynamic equilibrium for knowing the acceleration and forces involved in the system.	CO6	Apply
22	Illustrate the equations for motion of body in lift and on inclined plane for the unknown forces and tensions.	CO6	Apply
23	Determine the benefit of work and energy relation for the unknown forces in connected bodies.	CO6	Apply
24	Deduce the stiffness of a spring using the work done equation while the spring is compressed or in tension.	CO6	Analyze

23. SYLLABUS:

MODULE I	**Introduction to Engineering Mechanics** | **Number of Lectures: 12**
	2D Force Systems: Basic concepts, particle equilibrium; rigid body equilibrium; system of forces, coplanar concurrent forces, resultant, moment of forces and its application; couples and resultant of force system, equilibrium of system of forces, free body diagrams, equations of equilibrium of coplanar systems.
MODULE II	**Friction, Centroid and Centre of Gravity** | **Number of Lectures: 12**
	Friction: Types of friction, limiting friction, laws of friction, static and dynamic friction; motion of bodies, wedge friction, screw jack. **Centroid and Centre of Gravity:** Centroid of lines, areas and volumes from first principle, centroid of composite sections; centre of gravity and its implications, theorems of Pappus–Guldinus.
MODULE III	**Area moment of inertia and Mass moment of inertia .** |**Number of Lectures: 12**
	Area moment of inertia: Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections; Product of Inertia, Parallel Axis Theorem, Perpendicular Axis Theorem. **Mass Moment of Inertia:** Moment of Inertia of Masses, Transfer Formula for Mass Moments of Inertia, Mass moment of inertia of composite bodies.
MODULE IV	**Kinematics of Rigid Bodies** | **Number of Lectures: 12**
	Review of particle dynamics, rectilinear motion; Plane curvilinear motion (rectangular path, and polar coordinates). Relative and constrained motion. Impulse-momentum (linear, angular); impact (Direct and oblique).

MODULE V	**Kinetics of Rigid Bodies** | **Number of Lectures: 13**
	Kinetics of rigid bodies, basic terms, D' Alembert's principle and its applications in plane motion and connected bodies; instantaneous centre of rotation in plane motion and simple problems; work-kinetic energy, power, potential energy. work energy principle and its application in plane motion of connected bodies.

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.
5. K.Vijay Reddy, J. Suresh Kumar, "Singer's Engineering Mechanics Statics and Dynamics", B S Publishers, 1st Edition, 2013.

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=pages/mech-btech-course-syllabi-bt23

ELECTRONIC RESOURCES: :

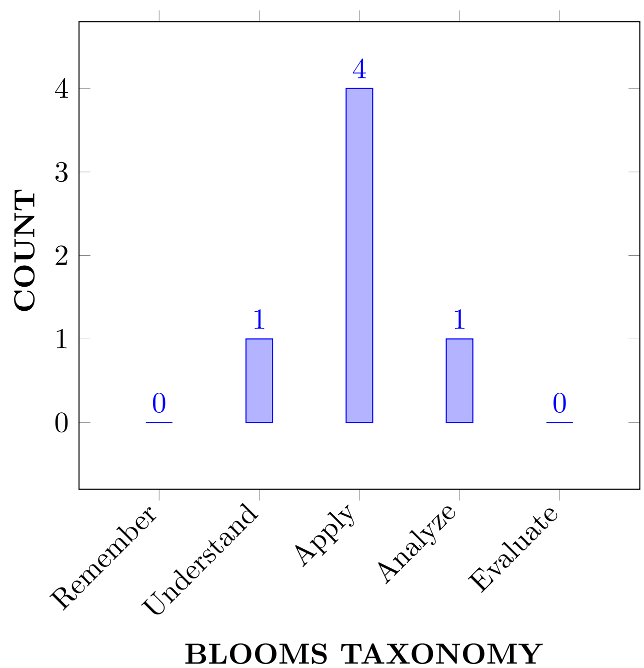
1. https://nptel.ac.in/courses/112106286.
2. https://akanksha.iare.ac.in/index?route=course/details&course_id=33.
3. https://akanksha.iare.ac.in/index?route=course/details&course_id=31.
4. https://akanksha.iare.ac.in/index?route=course/details&course_id=1293.

Materials Online:

1. Course Template
2. Tutorial Question Bank
3. Tech Talk Topics
4. Open End Experiments

5. Definitions and Terminology
6. Assignments
7. Model Question Paper-I
8. Model Question Paper-II
9. Lecture Notes
10. E-Learning Readiness Videos (ELRV)
11. Power Point Presentation

24. COURSE KNOWLEDGE COMPETENCY LEVEL



25. PROGRAM OUTCOMES & PROGRAM SPECIFIC 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
Program Specific Outcomes	
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

26. HOW PROGRAM OUTCOMES ARE ASSESSED:

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

27. 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	

3 = High; 2 = Medium; 1 = Low

28. 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	-	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-

29. 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 mathematics, science and Engineering fundamentals to problems for determining reactions, resultants and condition for equilibrium of structure using the knowledge of mathematics and science fundamentals.	2
	PO 2	Formulate the complex engineering problems to determine the reactions, resultants and condition for equilibrium of given force systems by identify the problem statement, formulation, data collection and validation for the analysis.	4
CO 2	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	2
	PO 4	Understand the technical concepts of D'Alembert's principle and interpret the equilibrium conditions for various applications.	4
	PSO 2	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	1

30. 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	-

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.6	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	30	-	-	-	-	-	-	-	-	-	-	-		-
CO 3	-	40	-	18.2	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	-	30	-	18.2	-	-	-	-	-	-	-	-	-	100	-

32. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

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

33. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO1, PO2, PO4, PSO2	SEE Exams	PO1, PO2, PO4, PSO1	Seminars	PO4, PSO2
Term Paper	-	5 Minutes Video	PO 4	Open Ended Experiments	PO 2, PO 4
Assignments	PO 2, PO 4				

34. ASSESSMENT METHODOLOGY INDIRECT:

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

35. COURSE PLAN:

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

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

S.No	Topics to be covered	CO's	Reference
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 due to friction 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	T2:7.7 R1:2.10
13	Friction in ladder applications	CO 2	T2:7.11
14	Friction in wedge applications	CO 2	T2:7.11
15	Screw jack, efficiency of a screw jack and condition for maximum efficiency	CO 2	T2:15.2 R1:8.2
16	Over hauling and self-locking screws, differential screw jack	CO 2	T2:15.7 R1:8.3.3
17	Centre of gravity, centroid, difference between centre of gravity and centroid	CO 3	T2:2.1 R1:7.9.2
18	Determination of centroid for simple sections	CO 3	T2:2.2 R1:7.9.1
19	Determination of centroid for composite sections	CO 3	T2:2.4 R1:7.11
20	Determination of centre of gravity of bodies, lines and arcs	CO 3	T2:16.8 R1:8.12.1
21	Moment of inertia, radius of gyration, polar moment of inertia, theorems of moment of inertia	CO 4	T2:15.13 R1:8.7.2
22	Moment of inertia from first principles	CO 4	T2:15.16 R1:8.7.3
23	Moment of inertia of standard sections and composite sections	CO 4	T1:11.9 R3:12.25
24	Mass moment of inertia, parallel axis theorem/transfer formula	CO 4	T1:3.2 R3:3.2
25	Mass moment of inertia of composite bodies I and L sections	CO 4	
26	Mass moment of inertia of composite bodies T and C sections	CO 4	
27	Review of particle dynamics, Rectilinear motion; Plane curvilinear motion	CO 5	
28	Plane curvilinear motion (polar coordinates).	CO 5	
29	3-D curvilinear motion; Relative and constrained motion	CO 5	
30	Kinetics – introduction, important terms, Newtons laws of motion, relation between force and mass	CO 5	T2:16.9 R1:8.11.1
31	D'Alembert's principle and its application in plane motion	CO 5	T2:16.9 R1:8.11.2

S.No	Topics to be covered	CO's	Reference
32	Motion of lift, motion of body on inclined plane	CO 6	T2:15.13 R1:8.7.2
33	D'Alembert's principle and its application for connected bodies	CO 6	T2:15.16 R1:8.7.3
34	Work, energy and power and units	CO 6	T1:11.9 R2:12.24
35	Work energy equation for translation	CO 6	T1:11.9 R3:12.25
36	motion of body on inclined plane problem solving using work energy method	CO 6	T1:11.9 R3:12.25
37	Work done by spring	CO 6	T1:3.2 R3:3.2
38	Linear impulse and momentum, conservation of momentum	CO 6	T1:3.3.1 R3:3.2
39	Impact of elastic bodies, impact and types of impact	CO 6	T2:16.5 R1:8.10
40	Coefficient of restitution, recoil of gun	CO 6	T2:16.5 R1:8.10
PROBLEM SOLVING/ CASE STUDIES			
1	Resultant of a force system	CO 1	
2	Equilibrium of bodies	CO 1	
3	Resultant by using Varignon's theorem	CO 2	
4	Frictional force implementation	CO 2	
5	Wedge friction and Screw jack	CO 2	
6	Centroid of simple and composite sections	CO 3	
7	Area moment of inertia of I, C, L and T sections	CO 3, CO 4	
8	Area moment of inertia of L and T sections	CO 3, CO 4	
9	Mass moment of inertia	CO 3, CO 4	
10	Rectilinear motion; Plane curvilinear motion	CO 5	
11	Plane curvilinear motion (polar coordinates).	CO 5	
12	3-D curvilinear motion; Relative and constrained motion	CO 5	
13	D'Alembert's principle for kinetic problems	CO 6	
14	Work energy equation for translation in plane motion and connected bodies	CO 6	
15	Impulse momentum for connected bodies and Impact of elastic bodies	CO 6	
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Introduction to Engineering Mechanics	CO 1	
2	Friction, Centroid, centre of gravity	CO 2, CO3	

S.No	Topics to be covered	CO's	Reference
3	Area moment of inertia and Mass moment of inertia	CO 3, CO 4	
4	Particle dynamics and work energy principle	CO 5	
5	Impulse momentum and mechanical vibrations	CO 6	
DISCUSSION OF TUTORIAL QUESTION BANK			
1	Introduction to Engineering Mechanics	CO 1	
2	Friction	CO 2, CO 3	
3	Centroid, centre of gravity and moment of inertia	CO 4	
4	Kinematics of Rigid Bodies	CO 5	
5	Kinetics of Rigid Bodies	CO 6	

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD, AE**
Dr. BDY Sunil, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**MECHANICAL ENGINEERING**			
2	Course Code	AHSD05			
3	Course Title	**ENGINEERING CHEMISTRY LABORATORY**			
4	Semester	II			
5	Regulations	BT-23			
6	Structure of the course	Practical			
		Lecture Hours			Practical Hours
		-			36
7	Course Offered	Odd Semester ✓		Even Semester ×	
8	Course Coordinator	Dr. B Divya			
9	Date Approved by BOS	24/08/2023			
10	Course Webpage	https://www.iare.ac.in/sites/default/files/BT23/AHSD05.pdf			
11	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**
		-	-	-	-

12. Course Overview

The course promotes the use of analytical tools from an engineering standpoint. It provides the overview of analytical techniques, and outline the importance of volumetric analysis, comprehensive instrumental analysis for properties of polymers, colorimetric analysis, and spectroscopic analysis. This practical approach gives the awareness to chemical methods and perform testing of materials in various industries.

13. Course Objectives:

The students will try to learn:

I	The quantitative analysis to know the strength of unknown solutions by instrumental methods.
II	The troubles of hard water and its estimation by analytical techniques
III	The applications of appropriate lubricant for finely tuned machinery
IV	The basic knowledge on synthesis of nanomaterials and its properties

14. Course Outcomes:

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

CO1	**U**se conductivity meter and potentiometer for measurement of conductance and electromotive force of solutions
CO2	**U**se PH meter for measurement of Strength of Acidic Solutions.
CO3	**M**ake use of the principles of water analysis for domestic and industrial applications.
CO4	**P**redict the Properties of polymeric materials by synthesizing the monomers
CO5	**U**se different types of lubricants to know its properties for the proper lubrication of machinery in industries.
CO6	**I**nterpret the absorption tendency of solids or liquids by using Colorimetry and spectroscopy techniques.

15. Employability Skills

1. **Project based skills:** Awareness on instrumental methods of analysis and real-time applications through properties of materials.

16. Content Delivery / Instructional Methologies:

✓	Day to Day lab evaluation	✓	Demo Video	✓	Viva Voce questions	x	Open Ended Experiments
x	Competitions	x	hackathons	x	Certifications	✓	Probing Further Questions

17. Evaluation Methodology:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks for internal assessment, continuous lab assessment will be done for 20 marks for the day today's performance including viva voce, 10 marks for the final internal lab assessment, and the remaining 10 marks for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) AppDevelopment (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report/Project and Presentation.

Table 1.0: CIA marks distribution

	Component			
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

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.

Table 2.0: Experiment based

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

Table 3.0: Programming based

Objective	Analysis	Design	Conclusion	Viva voce	Total

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

18. Course Content:

CO 1	**Use conductivity meter and potentiometer for measurement of conductance and electromotive force of solutions**
	1. Determine the Neutralization Point between Strong Acid against Strong Base 2. Estimate the Amount of Iron by Potentiometry 3. Determine the pH of the unknown solution by pH metry
CO 2	**Use PH meter for measurement of strength of acidic solutions.**
	1. Determine the pH of the unknown solution by pH metry
CO 3	**Make use of the principles of water analysis to control the hardness of water used in domestic and industrial purposes**
	1. Determination of chloride content of water by argentometry 2. Measurement of Total Dissolved Solids (TDS) in different water samples 3. Estimate the Total Hardness of water using EDTA
CO 4	**Predict the properties of polymeric materials by synthesizing the monomers.**
	1. Synthesize Thiokol rubber using sodium polysulphide with 1, 2-Dichloroethane.
CO 5	**Use the appropriate lubricant oil for the industrial machinery based on their properties.**
	1. Determine the Viscosity of the Lubricants using Red Wood Viscometer / Ostwald's Viscometer 2. Determine the Flash and Fire Points of Lubricants 3. Determine Cloud and Pour Points of Lubricants
CO 6	**Interpret the absorption tendency of solids or liquids using colorimetry and spectroscopic techniques.**
	1. Estimate the Metal Ion Concentration using Colorimeter 2. Characterization of Nanomaterials by UV-Visible Spectrophotometer

Note: One Course Outcome may be mapped to multiple number of experiments.

19. 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	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping ; Introduction to chemistry laboratory Safety guidelines to chemistry laboratory	CO 1	T2:10.31
2	Determine the neutralization point by titration of strong acid against strong base by conductometrically.	CO 1	T1:10.12 T2:10.31 R1:1.12.3
3	Studying the electrode potential measurements and estimate the amount of Fe^{2+} by using potentiometer.	CO 1	T2:10.31 R1:1.15
4	Determination of the pH of a given solution by pH metry	CO 1	T1:10.12 R1:1.16
5	Determination of chloride content of water by argentometry.	CO 2	T1:16.8 R1:1.13.1
6	Studying the water hardness and determine the Total Dissolved Solids (TDS) in each test liquid.	CO 3	T5:17.5 R1:1.13.2
7	Studying the specifications of water and estimate the total hardness of water by complexometric method	CO 3	T5:17.5 R1:1.13.3
8	Synthesize Thiokol rubber using sodium polysulphide with 1, 2-Dichloroethane.	CO 4	T3:2.6 R1:1.7.1
9	Studying the viscosity of lubricants and determine the viscosity of lubricants at various temperature using Red wood viscometer	CO 5	T1:19.10 R1:1.17.3
10	Determination of flash and fire points of lubricants by using Pensky Martens apparatus	CO 5	T1:19.10 R1:2.6.1
11	Determination of cloud and pour points of lubricants.	CO 5	T1:19.10 R1:2.6.2
12	Estimation of metals ion concentration by colorimetry	CO 6	T2:16.9 R1:2.10
13	Characterization of nanomaterials by using UV-visible spectrophotometer	CO 6	T2:16.9

20 Experiments for Enhanced Learning (EEL):

S.No	Design Oriented Experiments
1	To study the Beer Lambert's Law and utilize for the determination metal concentration in effluents by colorimetry
2	To study the absorption edges of metal complex using spectrophotometry
3	To study the iron content by potentiometry using different oxidizing agents

21. Program Outcomes & Program Specific 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.

Program Outcomes	
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
Program Specific Outcomes	
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.

22. 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	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 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	Laboratory experiments, internal and external lab examinations.

23. 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

24. 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	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-

25. 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 basic principle of conductance and EMF to make use of titrimetry to obtain graphical plots to determine the strength of acid by using principles of science and mathematical expression for solving engineering problems	3
	PO 2	Use basic principles of conductance and EMF to find the neutralization point that helps in interpretation of results..	2
CO 2	PO 1	Interpret the basic principles of pH metry to find the pH of unknown solutions and obtain graphical plots to determine the strength of acid by using principles of science and mathematical expressions or solving engineering problems.	3
	PO 2	Make use of pH metry and find the neutralization point that helps in interpretation of results.	2
CO 3	PO 1	Make use of coloured indicators to complex the metal ions, Investigate the concentration of hardness causing salts using Complexometry and argentometry methods by using principles of science and mathematical expression for solving engineering problems	3

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 2	Identify the problems of hard water and examine the total dissolved salts that provides information and data for its usage in industry.	2
	PO 7	Recognize the problems in industries by using hard water and its impact in socio economic and environmental contexts for sustainable development.	2
CO 4	PO 1	IExplain the polymerization process to synthesize the polymers from monomers by using principles of science and for solving engineering problems	2
CO 5	PO 1	Describe the physical properties of a lubricant and its determination using instrumental methods by using principles of science and mathematical expression for solving engineering problems	3
	PO 2	Extend the properties of lubricants with experimental collection of information and data in reaching conclusions by the interpretation of results.	2
CO 6	PO 1	Explain the principle of molecular transitions and make use of mathematical expression of Beer Lambert's Law colorimetry and UV-VIS spectroscopy by using principles of science and mathematical expression for solving engineering problems	3
	PO 2	Utilize graphical analysis of concentration versus absorbance for a given solution, and interpret the data, to provide valid conclusions regarding the quantitative analysis.	2

26. 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	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	2	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-

27. 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	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	20	-	-	-	-	66.6	-	-	-	-	-	-	-	-
CO 4	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-

28. 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 - $0 \le C \le 5\%$ – No correlation

2 - 40 % $< C < 60\%$ –Moderate

1-5 $< C \le 40\%$ – Low/ Slight

3 - $60\% \le C < 100\%$ – 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	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	2	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	17	10	-	-	-		-	-	-	-	-	-	-	-	-
AVERAGE	2.8	2	-	-	-	-	2	-	-	-	-	-	-	-	-

29. Assessment methodology direct:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

30. Assessment methodology indirect:

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

31. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1	NO POVERTY	
2	ZERO HUNGER	
3	GOOD HEALTH AND WELL-BEING	
4	QUALITY EDUCATION	**Quality Education:** Enhancement in the additional skills for the students with analytical tools.
5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	**Clean Water and Sanitation:** Ensures the availability to clean water through hard water analysis and its removal with chemical methodology
7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	

9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	
13	CLIMATE ACTION	
14	LIFE BELOW WATER	**Life Below Water:** Knowledge gained on the colorimetry provides awareness to students on the effect of metals from industrial effluents on living organisms in water bodies
15	LIFE ON LAND	
16	PEACE, JUSTICE AND STRONG INSTITUTIONS	

17	PARTNERSHIPS FOR THE GOALS	

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**MECHANICAL ENGINEERING**			
2	Course Title	**APPLIED PHYSICS LABORATORY**			
3	Course Code	AHSD09			
4	Program	B.Tech			
5	Semester	II Semester			
6	Regulation	BT-23			
7	Structure of the course	Practical			
		Practical Hours			Credits
		48			1
8	Course Offered	Odd Semester ×		Even Semester ✓	
9	Course Coordinator	Dr. K HARI PRASAD			
10	Date Approved by BOS	24/08/2023			
11	Course Webpage	www.iare.ac.in/?q=pages/btech-course-syllabi-bt23-cseaiml			
12	Course Prerequistes	**Level UG/PG**	**Course Code**	**Course Tittle**	**Semester**
		Intermediate	-	-	-

13. Course Overview

The aim of the course is to provide hands on experience for experiments in different areas of physics. This laboratory includes experiments involving electromagnetism and optoelectronics. This also develops student's expertise in applying physical concepts to practical problem and apply it for different applications.

14. COURSE OBJECTIVES:

The students will try to learn:

I	Familiarize with the lab facilities, equipment, standard operating procedures..
II	About the different kinds of functional magnetic materials which paves away 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 application characteristics of lasers and its propagation in optical fibre communication.

15. 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 and resistivity of a semiconductor diode using four probe method.
CO 2	**Illustrate** principle, working and application of wave propagation and compare the results of frequency with theoretical harmonics and overtones.
CO 3	**Investigate** the energy losses, curie temperature and properties associated with a given Ferro magnetic material
CO 4	**Examine** launching of light through optical fiber from the concept of light gathering capacity of numerical aperture and determine the divergence of Laser beam
CO 5	**Graph** V-I /L-I characteristics of various optoelectronic devices like Light Emitting diode, Solar cell at different intensities to understand their basic principle of functioning as well as to infer the value of Planck's constant
CO 6	**Analyse** the variation of magnetic field induction produced at various points along the axis of current carrying coil.

16. Employability Skills

1. **Project based:** Project based skills: Would be able to familiarize themselves with basic experiments and calculations that would inculcate the concept of learning by doing.

17. Content Delivery / Instructional Methologies:

✓	Day to Day lab evaluation	✓	Demo Video	✓	Viva Voce questions	✓	Open Ended Experiments
x	Competitions	x	hackathons	x	Certifications		Probing Further Questions

18. Evaluation Methodology:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

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.

Table 4: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
3	3	2	2	10	20

Table 5: Programming based

Objective	Analysis	Design	Conclusion	Viva voce	Total
					20

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

19. COURSE CONTENT SYLLABUS:

CO 1	**Identify the type of semiconductor using the principle of Hall effect and also determine the energy gap and resistivity of a semiconductor diode using four probe method.**
	1. Errors and Measurement 2. Hall Effect (Loreentz Force) 3. Energy gap of a Semiconductor diode 4. Resistivity -Four probe Method

CO 2	**Illustrate principle, working and application of wave propagation and compare the results of frequency with theoretical harmonics and overtones.**
	1. Melde's Experiment
CO 3	**Investigate the energy losses, curie temperature and properties associated with a given Ferro magnetic material.**
	1. B-H Curve With CRO 2. Magnetic Materials
CO 4	**Examine launching of light through optical fiber from the concept of light gathering capacity of numerical aperture and determine the divergence of Laser beam**
	1. Optical Fiber 2. Laser Divergence
CO 5	**Graph V-I /L-I characteristics of various optoelectronic devices like Light Emitting diode, Solar cell at different intensities to understand their basic principle of functioning as well as to infer the value of Planck's constant.**
	1. Solar Cell 2. Light Emitting Diode 3. Planck's Constant 4. Biassing Diode
CO 6	**Analyse the variation of magnetic field induction produced at various points along the axis of current carrying coil**
	1. Stewart's and Gee's Appratus

Note: One Course Outcome may be mapped to multiple number of experiments.

TEXTBOOKS

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

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

3. Dr. Rizwana, "Engineering Physics Manual", Spectrum Techno Press, 2018

REFERENCE BOOKS:

1. CF Coombs, "Basic Electronic Instrument Handbook", McGraw - HillBookCo.,1972.
2. CH Bernard and CD Epp, John Wiley and Sons, " Laboratory Experiments in College Physics"

20. 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	To estimate the error and uncertainty in measurement	CO 1	T1 :10.2
2	Study the phenomenon of Hall effect and determine the charge carrier density and Hall coefficient of a given sample	CO 1	T1:13.5
3	Determination of energy gap of a given semiconductor diode by measuring the variation of current as a function of temperature	CO 1	T1:16.8
4	Determination of the resistivity by forcing current through two outer probes and reading the voltage across the two inner probes of semiconductor by four probe method.	CO 1	T2:5.15 R1:1.16
5	Determination of frequency of a given tuning fork in longitudinal wave propagation and transverse mode of wave propagation	CO 2	T1:15.5 R1:1.13.1
6	Evaluate the energy loss per unit volume of a given magnetic material per cycle by tracing the hysteresis loop (B-H curve)	CO 3	T1:15.7
7	Determine the curie temperature (Tc) and relative permeability of a ferromagnetic materials.	CO 4	T1:15.8
8	Evaluation of numerical aperture and acceptance angle of a given optical fiber.	CO 4	T1:17.9
9	Determination of the beam divergence of the given laser beam	CO 4	T1:17.5
10	Studying the characteristics of solar cell at different intensities and determination of maximum workable power.	CO 5	T1:17.5
11	Studying V-I characteristics of LED in forward bias for different LEDs and measure the threshold voltage and forward resistance	CO 5	T1:19.10
12	Determination of Planck's constant by measuring threshold voltage of given LED.	CO 5	T1:19.10
13	Study the forward bias of LED and reverse bias of Photodiode	CO 5	T1:19.10
14	Study the magnetic field along the axis of current carrying coil – Stewart and Gee's method	CO 6	T1:14.7

21. Experiments for enhanced learning (EEL):

S.No	Design Oriented Experiments
1	To study the bending losses and transmission losses of an optical Fiber
2	To determine the mobility and conductivity of given semiconductor using Hall Effect
3	To Determine the resistivity of given ferromagnetic material using Two Probe method.

22. PROGRAM OUTCOMES & PROGRAM SPECIFIC 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.

Program Outcomes	
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
Program Specific Outcomes	
PSO 1	DFocus 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.

23. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering Knowledge** 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

24. 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

25. 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	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-

26. 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	PO1	Identify basic principle of Hall effect and make use of mathematical expression for Hall coefficient to deduce the type of semiconductor	3
	PO 2	Understand the given problem statement of variation of resistance with temperature in a semiconductor diode and formulate Resistivity from experimental collection of information and data in reaching substantial conclusions by the interpretation of results.	4
	PO 4	Make use of graphical analysis of current versus temperature curve for a given semiconductor, and interpret the data, to provide valid conclusions regarding the energy gap in a given semiconductor	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.	1
CO 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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 3	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 effect of temperature on a given ferromagnetic material and formulate Curie temperature and relative permittivity from experimental collection of information and data in reaching substantial conclusions by the interpretation of results.	4
CO 4	PO 1	Interpret launching of light through optical fibre and make use of mathematical expression for analysing light gathering capacity through numerical aperture	2
	PO 2	Understand the given problem statement on directionality of laser light in comparison with ordinary light and formulate the divergence of a given laser source from experimental collection of information and data in reaching substantial conclusions by the interpretation of results.	3
CO 5	PO 1	Understand the phenomenon of recombination of electron-hole pair and determine the value of threshold voltage of a given LED	1
	PO 2	Understand the given problem statement of conversion light energy to electrical energy and formulate V-I characteristics of solar cell from experimental collection of information and data in reaching substantial conclusions by the interpretation of results.	2
	PO 4	Analyse and interpret the data obtained by using different LED's and synthesise the information to infer the value of Planck's constant	2
CO 6	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

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

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

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

COURSE OUTCOMES	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	PROGRAM OUTCOMES												PSO'S		
CO 1	66	40	-	18	-	-	-	-	-	-	-	-	-	-	-
CO 2	66	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	66	40	-	18	-	-	-	-	-	-	-	-	-	-	-
CO 6	66	40	-	-	-	-	-	-	-	-	-	-	-	-	-

29. 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	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	PROGRAM OUTCOMES												PSO'S		
CO 1	3	1	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	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
CO 6	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	11	6	-	2	-	-	-	-	-	-	-	-	-	-	-
AVERAGE	1.8	1	-	1	-	-	-	-	-	-	-	-	-	-	-

30. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	✓

31. ASSESSMENT METHODOLOGY INDIRECT:

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

32. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1		-
2		-
3		-
4		**Quality Education:In order to ensure inclusive and equitable quality education and promote life long learning oppurtunities for all, foundation is very much important. Physics laboratory comes under basic science course falicitating students to gain and ascertain basic knowledge which will help them to envisage to their higher education**
5		-

6	CLEAN WATER AND SANITATION	-
7	AFFORDABLE AND CLEAN ENERGY	-
8	DECENT WORK AND ECONOMIC GROWTH	-
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	-.
10	REDUCED INEQUALITIES	-
11	SUSTAINABLE CITIES AND COMMUNITIES	-
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	-
13	CLIMATE ACTION	-
14	LIFE BELOW WATER	-
15	LIFE ON LAND	-

16	PEACE, JUSTICE AND STRONG INSTITUTIONS	-
17	PARTNERSHIPS FOR THE GOALS	-

Approved by: Board of Studies in the meeting conducted on24/08/2023

Signature of Course Coordinator **HOD ME**
Dr. K HARI PRASAD, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COMPUTER AIDED ENGINEERING DRAWING

<table>
<tr><td>1</td><td>Department</td><td colspan="4">MECHANICAL ENGINEERING</td></tr>
<tr><td>2</td><td>Course Title</td><td colspan="4">COMPUTER AIDED ENGINEERING DRAWING</td></tr>
<tr><td>3</td><td>Course Code</td><td colspan="4">AMED05</td></tr>
<tr><td>4</td><td>Program</td><td colspan="4">B.Tech</td></tr>
<tr><td>5</td><td>Semester</td><td colspan="4">II Semester</td></tr>
<tr><td>6</td><td>Regulation</td><td colspan="4">BT-23</td></tr>
<tr><td rowspan="3">7</td><td rowspan="3">Structure of the course</td><td colspan="4">Practical</td></tr>
<tr><td colspan="3">Tutorial Hours</td><td>Practical Hours</td></tr>
<tr><td colspan="3">1</td><td>2</td></tr>
<tr><td>8</td><td>Course Offered</td><td colspan="2">Odd Semester ×</td><td colspan="2">Even Semester ✓</td></tr>
<tr><td>9</td><td>Course Coordinator</td><td colspan="4">Dr. C Labesh Kumar</td></tr>
<tr><td>10</td><td>Date Approved by BOS</td><td colspan="4">26/02/2024</td></tr>
<tr><td>11</td><td>Course Webpage</td><td colspan="4">www.iare.ac.in/—-/—-</td></tr>
<tr><td rowspan="3">12</td><td rowspan="3">Course Prerequistes</td><td>Level</td><td>Course Code</td><td>Semester</td><td>Prerequisites</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>-</td></tr>
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</table>

13. COURSE OVERVIEW

Engineering Drawing is the technique that develops the ability to visualize any object with all physical and dimensional configurations. It 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.

14. COURSE OBJECTIVES

The students will try to learn:

I	To develop the ability of visualization of different objects through technical drawings
II	To acquire computer drafting skill for communication of concepts, ideas in the design ofengineering products

15. COURSE OUTCOMES

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

CO 1	Demonstrate the use of draw, modify and dimension commands of AutoCAD for development of 2D and 3D drawings.
CO 2	Construct the scales, conic sections and special curves used in engineering applications.
CO 3	Apply the principles of orthographic projection for projections of points, lines,planes and regular solids.
CO 4	Develop the lateral surfaces of solids for producing the joints and ducts used in industries.
CO 5	Use the concept of orthographic projections for converting isometric views for understanding technical drawings.
CO 6	Use the concept of isometric projections for converting orthographic views for engineering applications.

16. EMPLOYABILITY SKILLS

1. **Problem-Solving and Critical Thinking:** Engineering Drawing involves CFD analysis and structural analysis of structures before inspection of prototype. This cultivates the ability to think critically and find innovative solutions, which is a fundamental skill sought by employers before finalization of product design in industries.
2. **Employment Advantage:** This can give competitive advantage when seeking employment as Design Engineer.
3. **Safety Awareness:** The analysis, decides the safety factor for the machine member when subjected to static and dynamic forces which enhances safety consciousness. Graduates should consider this awareness in every engineering industry where safety is a priority.

17. CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES

✓	 Day to Day lab evaluation	✓	 Demo Video	✓	 Expected Viva Voce questions	✓	 Open Ended Experiments
X	 Competitions	X	 hackathons	✓	 Certifications	✓	Probing Further Questions

18. EVALUATION METHODOLOGY

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

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.

Table 4: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
					20

Table 5: Programming based

Objective	Analysis	Program	Results	Viva voce	Total
4	4	6	4	2	20

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

19. COURSE CONTENT

CO 1	**Demonstrate the use of draw, modify and dimension commands of AutoCAD for development of 2D and 3D drawings**
	1. Introduction to CAD 2. Introduction to Engineering Drawing 3. Exercises on Dimensioning 4. Exercises on Geometrical Constructions
CO 2	**Construct the scales, conic sections and special curves used in engineering applications.**
	1. Exercises on Conic Sections and Scales
CO 3	**Apply the principles of orthographic projection for projections of points, lines, planes and regular solids.**
	1. Exercises on lines 2. Exercises on Planes 3. Exercises on soilds
CO 4	**Develop the lateral surfaces of solids for producing the joints and ducts used in industries.**
	1. Exercise on Development of surfaces-1 (Prisms) 2. Exercise on Development of surfaces-2 (Cylinder, Cone and Pyramid)
CO 5	**Use the concept of orthographic projections for converting isometric views for understanding technical drawings.**
	1. Exercise on orthographic views
CO 6	**Use the concept of isometric projections for converting orthographic views for engineering applications.**
	1. Exercise on isometric projections of solids

Note: One Course Outcome may be mapped to multiple number of experiments.

Text Books

1. Frederick E Giesecke, Alva Mitchell, Henry C Spencer, Ivan L Hill, John T Dygdon, James E. Novak, R. O. Loving, Shawna Lockhart, Cindy Johnson" *Technical Drawing with Engineering Graphics*", Pearson Education, 16th Edition, 2016.

2. Donald Hearn "*Computer Graphics*", Pearson Education, 12th Edition, 2021.

Reference Books

1. Basant Agrawal and C M Agrawal "*Engineering Drwing*", 3 rd Edition, Mc GraHill, 2018.
2. James M. Leake, Molly Hathaway Goldstein, Jacob L. Borgerson, "*Engineering Design Graphics, Modelling and Visualization* ", Wiley Publications, 3 rd Edition, 2020.

Materials Online

1. Lecture notes, ELRV videos and power point presentations
2. Answers / solutions to all questions / problems in the textbook
3. Online exercises
4. Problems and solutions in files

20. COURSE PLAN

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

S.No	Topics to be covered	CO's
1	Introduction to AUTOCAD	CO 1
2	Introduction to Engineering Drawing	CO 1
3	Exercises on Geometrical Constructions	CO 1
4	Exercises on Conic Sections	CO 1
5	Principles of orthographic projections, conventions	CO 2
6	Projections of points and lines	CO 2
7	Projections of planes	CO 2
8	Projections of regular solids	CO 3
9	Exercises on prism, cylinder, pyramid, cone	CO 3
10	Exercise on Development of surfaces-1(Prisms)	CO 4
11	Exercise on Development of surfaces-2 (Cylinder, Cone, Pyramid)	CO 4
12	Exercise on Isometric projection of Planes	CO 5
13	Exercise on Isometric projection of Solids	CO 5
14	Demonstration of Ortho to Isometric and Isometric to Ortho	CO 6

Experiments for enhanced learning (EEL):

S.No	Design Oriented Experiments
1.	Develop the procedure to draw knuckle joint by using AUTO CAD.
2.	Develop the standard procedure to draw 2D drawing of any machine component by using AUTO CAD.

21. PROGRAM OUTCOMES & PROGRAM SPECIFIC 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

Program Specific Outcomes	
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.

22. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	1	LAB PROGRAMS/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 PROGRAMS/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	LAB PROGRAMS/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.	3	LAB PROGRAMS/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 PROGRAMS/CIE/SEE
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	3	LAB PROGRAMS/CIE/SEE

23. 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 PROGRAMS/CIE/SEE

3 = High; 2 = Medium; 1 = Low

24. 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	-	✓	-	-	-	✓	-	✓	-	-	-	-	-	-	-

25. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	1
	PO 5	Create, select, and apply appropriate techniques, resources, and modern engineering and CAD tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	1
	PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	1

COURSE OUTCOMES	PO'S PSO'S	**Justification for mapping (Students will be able to)**	No. of Key Competencies
CO 2	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	1
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	7
CO 3	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	7
	PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	4
CO 4	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	7
	PO 3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	6
CO 5	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	7
	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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 6	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	7
	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
	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	4

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

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	33.3	-	-	-	100	-	-	-	-	-	-	-	-	-	33.33
CO 2	33.3	70	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	33.3	70	-	-	-	-	-	-	-	-	-	-	-	-	33.33
CO 4	-	70	60	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	70	-	-	-	20	-	-	-	-	-	-	-	-	-
CO 6	-	70	-	-	-	60	-	66.6	-	-	-	-	-	-	

28. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

2 - $40\% < C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

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

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

29. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

30. ASSESSMENT METHODOLOGY INDIRECT:

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

31.RELEVANCE TO SUSTAINABILITY GOALS

Write brief description about the course and how its relevance to SDGs.

X	NO POVERTY	
X	ZERO HUNGER	
X	GOOD HEALTH AND WELL-BEING	
✓	QUALITY EDUCATION	**Quality Education:** The students can gain a deeper understanding of how technology can be harnessed to address global challenges. This promotes quality education by fostering critical thinking and problem-solving skills in the context of sustainable development.
X	GENDER EQUALITY	
X	CLEAN WATER AND SANITATION	
X	AFFORDABLE AND CLEAN ENERGY	
X	DECENT WORK AND ECONOMIC GROWTH	

✓	INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Industry, Innovation, and Infrastructure:** Java programming skills are essential for developing innovative software solutions. Students working on projects related to sustainable development can contribute to building resilient infrastructure and promoting inclusive and sustainable industrialization.
X	REDUCED INEQUALITIES	
✓	SUSTAINABLE CITIES AND COMMUNITIES	**Sustainable Cities and Communities:** Java programming plays a crucial role in developing applications for smart cities, efficient transportation, and waste management systems. Through projects in the lab, students can explore ways to create more sustainable urban environments.
X	RESPONSIBLE CONSUMPTION AND PRODUCTION	
✓	CLIMATE ACTION	**Climate Action:** Students can create climate-related applications, such as carbon footprint calculators or climate data analysis tools, using Java programming. This directly contributes to SDG 13 by raising awareness and facilitating climate action.
X	LIFE BELOW WATER	
X	LIFE ON LAND	
X	PEACE, JUSTICE AND STRONG INSTITUTIONS	

✓	PARTNERSHIPS FOR THE GOALS	**Partnerships for the Goals:** Collaborative projects can foster partnerships among students, educators, and local communities. These partnerships enhance knowledge sharing and the development of innovative solutions that align with multiple SDGs.

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD, ME**
Dr. C Labesh Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**MECHANICAL ENGINEERING**			
2	Course Title	**PROGRAMMING FOR PROBLEM SOLVING LABORATORY**			
3	Course Code	ACSD06			
4	Program	B.Tech			
5	Semester	II Semester			
6	Regulation	BT-23			
7	Structure of the course	Practical			
		Tutorial Hours		Practical Hours	
		1		2	
8	Course Offered	Odd Semester ×		Even Semester ✓	
9	Course Coordinator	Dr. Praveen Kumar Balguri			
10	Date Approved by BOS	25/09/2023			
11	Course Webpage	www.iare.ac.in			
12	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**
		UG	ACSD02	I	OOPJL

13. COURSE OVERVIEW

The course is structured to impart essential programming skills and problem-solving strategies essential for addressing a diverse array of computational challenges. By engaging in practical programming exercises, you will gain proficiency in coding, problem analysis, and solution development using a variety of tools. This course enables individuals to automate tasks and devise inventive solutions for intricate challenges.

14. COURSE OBJECTIVES

The students will try to learn:

I	The fundamental programming constructs and understand the utilization of collection data types in Python.
II	A comprehensive understanding of data structures and algorithms in software development, enabling effective problem-solving skills.
III	The principles of graph theory and apply this knowledge adeptly to address diverse practical problems across various disciplines.
IV	the skills essential for the effective application of numerical methods in solving a broad spectrum of mathematical and scientific problems.

15. COURSE OUTCOMES

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

CO1	Adapt programming concepts and skills using python programming.
CO2	Demonstrate the ability to foster critical thinking and problem-solving skills through addressing complex problems.
CO3	Gain a solid understanding of fundamental data structures like stacks,queues,trees for effective problem-solving skills.
CO4	Apply graph routing and shotest path algorithms to solve real world problems.
CO5	Develop problem-solving skills and the ability to solve graph-related challenges like graph coloring,traversals.
CO6	Exposed to various numerical integration techniques to tackle a wide range of computational problems.

16. EMPLOYABILITY SKILLS

1. **Problem-Solving and Critical Thinking:** Students learn to analyze complex problems, design solutions using object-oriented principles, and translate real-world scenarios into code.
2. **Debugging and Troubleshooting:** Debugging challenges in the lab help students master error identification, interpretation, and use of debugging tools, essential for real-world software development.

17. CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES

✓	Day to Day lab evaluation	✓	Demo Video	✓	Expected Viva Voce questions	✓	Open Ended Experiments
X	Competitions	X	hackathons	✓	Certifications	✓	Probing Further Questions

18. EVALUATION METHODOLOGY

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

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.

Table 4: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
					20

Table 5: Programming based

Objective	Analysis	Program	Results	Viva voce	Total
4	4	6	4	2	20

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

19. COURSE CONTENT

CO 1	**Summarize programming concepts and skills needed for a solid foundation in python programming through hands on coding exercises.**
	1. Getting Started Exercises
CO 2	**Develop the ability to solve a variety of programming problems and algorithms using python.**
	1. Exercises on simple problems using lists, tuples, sets and dictionaries.
CO 3	**Understand complex and custom data structures to solve real-world problems.**
	1. Exercises on implementation of stacks 2. Exercises on implementation of queues
CO 4	**Demostrate proficiency implementing graph algorithms to solve variety of problems and scenarios.**
	1. Exercises on graph representaion 2. Exercises on implementation of graph routing algorithms 3. Exercises on shortest path algorithms
CO 5	**Build critical thinking skills to solve the various real-world applications to using graph theory**
	1. Exercises on graph colouring 2. Exercises on graph traversals 3. Exercises on minimum spanning trees
CO 6	**Learn the importance of numerical methods and apply those thinking skills to tackle a wide range of computational problems..**
	1. Exercises on roots of quadratic equations 2. Exercises on numerical integration 3. Exercises on ordinary differential equations

Note: One Course Outcome may be mapped to multiple number of experiments.

Text Books

1. Eric Matthes."*Python Crash Course: A Hands-On, Project-based Introduction to Programming*", No Starch Press, 3rd Edition, 2023.

2. John M Zelle "*Python Programming: An Introduction to Computer Science*" Ingram short title, 3rd Edition, 2016.

Reference Books

1. Martin C. Brown. "*Python: The Complete Referencel*", Mc. Graw Hill, Indian Edition, 2018.
2. Paul Barry "*Head First Python: A Brain-Friendly Guide*", O'Reilly, 2nd Edition, 2016
3. Taneja Sheetal, Kumar Naveen "*Python Programming – A Modular Approach*", Pearson, 1st Edition, 2017.
4. R Nageswar Rao "*Core Python Programming*", Dreamtech Press, 2018.

Materials Online

1. https://realPython.com/python3-object-oriented-programming/
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/

20. COURSE PLAN

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

S.No	Topics to be covered	CO's
1	Getting Started Exercises	CO 1
2	Exercises on Matrix Operations	CO 1
3	Exercises on Stack	CO 3
4	Exercises on Queue	CO 2
5	Exercises on Graph Representation	CO 4
6	Exercises on Graph Routing Algorithms	CO 4
7	Exercises on Shortest Path Algorithms	CO 3
8	Exercises on Graph Coloring	CO 5
9	Exercises on Graph Traversal	CO 4
10	Exercises on Minimum Spanning Tree (MST)	CO 4
11	Exercises on Roots of Equations	CO 5
12	Exercises on Numerical Integration	CO 5
13	Ordinary Differential Equations-The Euler Method	CO 6
14	Ordinary Differential Equations-Runge-Kutta 2 Order Method	CO 6

Experiments for enhanced learning (EEL):

S.No	Design Oriented Experiments
1.	Implement error handling to catch file-related exceptions.
2.	Call a custom function that takes parameters and returns a value.
3.	Read data from a text file, perform some operation, and write the result back to a new file.
4.	Implement a program to add, remove, and manipulate elements in a list.
5.	Use list comprehensions to generate new lists.

21. PROGRAM OUTCOMES & PROGRAM SPECIFIC 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.
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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.
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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
Program Specific Outcomes	
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 interdisciplinary engineering applications.
PSO 3	Make use of computational and experimental tools for building career paths towards innovation startups, employability and higher studies.

22. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	LAB PROGRAMS/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 PROGRAMS/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 PROGRAMS/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.	1	LAB PROGRAMS/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.	1	LAB PROGRAMS/CIE/SEE

23. 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	LAB PROGRAMS/CIE/SEE
PSO 3	Make use of computational and experimental tools for building career paths towards innovation startups, employability and higher studies.	1	LAB PROGRAMS/CIE/SEE

3 = High; 2 = Medium; 1 = Low

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

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

25. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	1
	PO 2	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 5	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
	PSO 1	Focus on ideation and research towards digital manufacturing in product development using additive manufacturing, computer numerical control simulation and high speed machining.	2
	PSO 3	Make use of computational and experimental tools for building career paths towards innovation startups, employability and higher studies.	1
CO 2	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	1
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3
	PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2
	PSO 1	Focus on ideation and research towards digital manufacturing in product development using additive manufacturing, computer numerical control simulation and high speed machining.	1
	PSO 3	Make use of computational and experimental tools for building career paths towards innovation startups, employability and higher studies.	1
CO 3	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 2	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 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3
	PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1
	PSO 1	Focus on ideation and research towards digital manufacturing in product development using additive manufacturing, computer numerical control simulation and high speed machining.	1
	PSO 3	Make use of computational and experimental tools for building career paths towards innovation startups, employability and higher studies.	2
CO 4	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2
	PO 2	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 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3
	PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1
	PSO 1	Focus on ideation and research towards digital manufacturing in product development using additive manufacturing, computer numerical control simulation and high speed machining.	2
	PSO 3	Make use of computational and experimental tools for building career paths towards innovation startups, employability and higher studies.	1
CO 5	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2
	PO 2	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 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3
	PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1
	PSO 1	Focus on ideation and research towards digital manufacturing in product development using additive manufacturing, computer numerical control simulation and high speed machining.	1
	PSO 3	Make use of computational and experimental tools for building career paths towards innovation startups, employability and higher studies.	2
CO 6	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 2	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 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3
	PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1
	PSO 1	Focus on ideation and research towards digital manufacturing in product development using additive manufacturing, computer numerical control simulation and high speed machining.	1
	PSO 3	Make use of modern computer tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	1

26. 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
Key Competencies	3	10	10	11	1	5	3	3	12	5	12	12	3	2	3
CO 1	1	2	-	-	1	-	-	-	-	-	-	-	2	-	1
CO 2	1	3	2	-	-	-	-	-	-	-	-	-	1	-	1
CO 3	2	2	3	2	1	-	-	-	-	-	-	-	1	-	2
CO 4	2	2	3	2	1	-	-	-	-	-	-	-	2	-	1
CO 5	2	2	3	2	1	-	-	-	-	-	-	-	1	-	2
CO 6	2	2	3	2	1	-	-	-	-	-	-	-	1	-	1

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	33.3	20	-	-	100	-	-	-	-	-	-	-	66.7	-	33.7
CO 2	33.3	30	20	-	-	-	-	-	-	-	-	-	33.7	-	33.7
CO 3	33.3	20	30	18	100	-	-	-	-	-	-	-	33.7	-	66.7
CO 4	66.7	20	30	18	100	-	-	-	-	-	-	-	66.7	-	33.7
CO 5	66.7	20	30	18	100	-	-	-	-	-	-	-	33.7	-	66.7
CO 6	66.7	20	30	18	100	-	-	-	-	-	-	-	33.7	-	33.7

28. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

2 - 40 % $< C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	2	-	-	1	-	-	-	-	-	-	-	2	-	1
CO 2	1	3	2	-	-	-	-	-	-	-	-	-	1	-	1
CO 3	2	2	3	2	1	-	-	-	-	-	-	-	1	-	2
CO 4	2	2	3	2	1	-	-	-	-	-	-	-	2	-	1
CO 5	2	2	3	2	1	-	-	-	-	-	-	-	1	-	2
CO 6	2	2	3	2	1	-	-	-	-	-	-	-	1	-	1
TOTAL	10	13	14	8	5	-	-	-	-	-	-	-	9	-	8
AVERAGE	1.66	2.16	2.33	1.33	0.83	-	-	-	-	-	-	-	1.5	-	1.33

29. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

30. ASSESSMENT METHODOLOGY INDIRECT:

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

31.RELEVANCE TO SUSTAINABILITY GOALS

Write brief description about the course and how its relevance to SDGs.

1		
2		
3		
4		**Quality Education:** The students can gain a deeper understanding of how technology can be harnessed to address global challenges. This promotes quality education by fostering critical thinking and problem-solving skills in the context of sustainable development.
5		
6		
7		
8		

9		**Industry, Innovation, and Infrastructure:** Python programming skills are essential for developing innovative software solutions. Students working on projects related to sustainable development can contribute to building resilient infrastructure and promoting inclusive and sustainable industrialization.
10		
11		**Sustainable Cities and Communities:** Python programming plays a crucial role in developing applications for smart cities, efficient transportation, and waste management systems. Through projects in the lab, students can explore ways to create more sustainable urban environments.
12		
13		**Climate Action:** Students can create climate-related applications, such as carbon footprint calculators or climate data analysis tools, using python programming. This directly contributes to SDG 13 by raising awareness and facilitating climate action.
14		
15		
16		**Peace, Justice, and Strong Institutions:** Python programming skills can be applied to create tools for transparency, accountability, and data security. By focusing on ethical coding practices, the lab can contribute to strong and just institutions.

17	PARTNERSHIPS FOR THE GOALS	**Partnerships for the Goals:**Collaborative projects can foster partnerships among students, educators, and local communities. These partnerships enhance knowledge sharing and the development of innovative solutions that align with multiple SDGs.

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD,ME**
Dr. Praveen Kumar Balguri, Associate Professor,AE

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

COURSE TEMPLATE

1	Department	**MECHANICAL ENGINEERING**			
2	Course Title	**WEB AND MOBILE APPLICATIONS DEVELOPMENT**			
3	Course Code	ACSD07			
4	Program	B.Tech			
5	Semester	II Semester			
6	Regulation	BT-23			
7	Structure of the course	Practical			
		Tutorial Hours		Practical Hours	
		0		3	
8	Course Offered	Odd Semester ×		Even Semester ✓	
9	Course Coordinator	Dr. D.Durga Bhavani			
10	Date Approved by BOS	25/08/2023			
11	Course Webpage	www.iare.ac.in/—-/—-			
12	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**
		-	-	-	-
		-	-	-	-

13. COURSE OVERVIEW
This course offers fundamental for understanding mobile application design and web development. It covers the concepts of HTML, CSS, JavaScript, Android framework and builds upon the Android development platform. Students will gain the knowledge to develop and deploy their own web and mobile applications.

14. COURSE OBJECTIVES:
The students will try to learn:

I	The characteristics, systematic methods, model for developing web applications
II	The fundamentals of HTML and CSS to design static and dynamic web pages.
III	The concepts of client side programming with Bootstrap, JavaScript, Ajax , Design user interfaces that follow best practices for usability and user experience
IV	The mobile application development for different platforms using appropriate tools and frameworks.
V	The user interface design with best practices for usability and user experience

15. COURSE OUTCOMES:

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

CO I	Create a web page with different layouts including links by applying different styles and colors to produce specified outputs
CO 2	Design and implement web and mobile applications to meet client requirements.
CO 3	Use coherent knowledge of web and mobile app development to evaluate contemporary and emerging web and mobile technologies.
CO 4	Apply layout management and multi layout techniques to create adaptable user interface.
CO 5	Design and manage databases in support of web and mobile applications
CO 6	Identify ethical, legal, and security issues related to web and mobile development.

16. EMPLOYABILITY SKILLS

1. **Problem-Solving and Analytical Thinking:** Web design is an incredibly popular and lucrative profession. As businesses are moving online, the demand for web design professionals is going up quickly. Organizations depend on their online storefronts to boost the bottom line, and customer expectations are high when it comes to interacting with professional websites.

17. CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES

✓	Day to Day lab evaluation	✓	Demo Video	✓	Expected Viva Voce questions	✓	Open Ended Experiments
X	Competitions	**X**	hackathons	✓	Certifications	✓	Probing Further Questions

18. EVALUATION METHODOLOGY

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

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.

Table 4: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
					20

Table 5: Programming based

Objective	Analysis	Program	Results	Viva voce	Total
4	4	6	4	2	20

Semester End Examination:

The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.

In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program

3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

19. COURSE CONTENT

CO 1	**Create a web page with different layouts including links by applying different styles and colors to produce specified outputs.**
	1. Getting Started Exercises 2. Exercises on java script
CO 2	**Design and implement web and mobile applications to meet client requirements.**
	1. Online Recruitment System 2. Student Counseling Management System 3. Data Mart Management System
CO 3	**Use coherent knowledge of web and mobile app development to evaluate contemporary and emerging web and mobile technologies.**
	1. Restaurant Reservation and Table Management Solutions 2. Secure Stock Exchange System using Web Services 3. Country Cargo and Express Couriers
CO 4	**Apply layout management and multi layout techniques to create adaptable user interface**
	1. Food ordering application 2. Music player application
CO 5	**Design and manage databases in support of web and mobile applications.**
	1. Smart Health Prediction 2. Hostel Management Application

CO 6	**Identify ethical, legal, and security issues related to web and mobile development.**
	1. Stay safe women security application 2. Controlling Anti Ragging Application 3. Extracurricular Event Tracking Application 4. Student management system 5. Pharm easy application 6. News Application

Note: One Course Outcome may be mapped to multiple number of experiments.

TEXTBOOKS

1. Thomas A. Powell."*The Complete Reference*", HTML and CSS, 5th Edition, 2017

2. Elisabeth Robson , Eric Freeman. "*Head First HTML and CSS: A Learner's Guide to Creating Standards-Based Web Pages*" 2nd Edition, 2012.

3. Adam Boduchand Roy Derks. "*React and React Native: A Complete Hands-on Guide to Modern Web and Mobile Development with React.js*" 3rd Edition, 2020.

4. RetoMeier. "*ProfessionalAndroid 4 Application Development*" 1st Edition, Wile Publication.

REFERENCE BOOKS:

1. W Hans Bergsten. "*Java Server Pages*", O'Reilly, 3rdEdition, 2003
2. D. Flanagan. "*Java Script*", O'Reilly, 6th Edition, 2011
3. Jon Duckett. "*Beginning Web Programming*", WROX, 2ndEdition, 2008.
4. Bill Phillips and Chris Stewart. "*Android Programming*", The Big Nerd Ranch Guide, 3rd Edition, 2017.
5. Dawn Griffiths, David Griffiths. "*Head First Android Development: A Brain-Friendly Guide*", 2017
6. Antonio Leiva. "*Kotlin for Android Developers: Learn Kotlin while developing an Android App*", CreateSpace Independent Publishing, 2016

MATERIALS ONLINE:

1. https://www.codecademy.com/learn/paths/web-development/
2. https://nptel.ac.in/courses/106/105/106105084/
3. https://www.javatpoint.com/android-tutorial
4. https://www.tutorialspoint.com/android/index.htm

20. COURSE PLAN:

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

S.No	Topics to be covered	CO's
1	Getting Started Exercises	CO 1
2	Exercises on java script	CO 1
3	Online Recruitment System	CO1 to CO6
4	Student Counseling Management System	CO1 to CO6
5	Data Mart Management System	CO1 to CO6
6	Restaurant Reservation and Table Management Solutions	CO1 to CO6
7	Secure Stock Exchange System using Web Services	CO1 to CO6
8	Country Cargo and Express Couriers	CO1 to CO6
9	Food ordering application	CO1 to CO6
10	Music player application	CO1 to CO6 3
11	Smart Health Prediction	CO1 to CO6
12	Hostel Management Application	CO1 to CO6
13	Stay safe women security	CO1 to CO6
14	Controlling Anti Ragging Application	CO1 to CO6
15	Extracurricular Event Tracking Application	CO1 to CO6
16	Student management system	CO1 to CO6
17	Extracurricular Event Tracking Application	CO1 to CO6
18	News Application	CO1 to CO6

Experiments for enhanced learning (EEL):

S.No	Design Oriented Experiments
1.	Develop the code using JavaScript for student information system. Student registration number should not be negative, if that is the case it should display a message using popup window.

2.	Write down the program to create a state component and subscribe button , when clicked the button to display thank you message.
3.	Build an HTML page to form a table to show the values in a tabular form with heading as Roll No., Student name, Subject Name, and values as Ram, Physics Shyam, Math Murli, Chemistry.
4.	Build a basic bootstrap table that has a light padding and only horizontal dividers.
5.	Build a script that inputs three integers from the user and displays sum, average, product, smallest and largest of these numbers in an alert dialog.

21. PROGRAM OUTCOMES & PROGRAM SPECIFIC 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.

Program Outcomes	
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
Program Specific Outcomes	
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.

22. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	LAB PROGRAMS/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 PROGRAMS/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 PROGRAMS/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 PROGRAMS/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.	1	LAB PROGRAMS/CIE/SEE
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	3	LAB PROGRAMS/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 (Communication). "Students should demonstrate the ability to communicate effectively in writing / Orally."	3	LAB PROGRAMS/CIE/SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	1	LAB PROGRAMS/CIE/SEE

23. 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 PROGRAMS/CIE/SEE

3 = High; 2 = Medium; 1 = Low

24. 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	✓	✓	✓	-	✓	-	-	✓	-	✓	-	✓	-	-	✓

25. 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 science, engineering fundamentals, and an engineering specialization to create a web page to produce specified outputs to the solutions of complex engineering problems.	3
	PO 2	Identify and analyze complex engineering problems reaching substantiated conclusions using first principles of natural sciences, and engineering sciences to create a web page to produce specified outputs.	3
	PO 3	Design solutions using web pages for complex engineering problems and design system components that meet the specified needs with appropriate consideration for the societal, and environmental considerations.	2
	PO 5	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
CO 2	PO 1	Apply the knowledge of science, engineering fundamentals, and an engineering specialization to create a web page to produce specified outputs to the solutions of complex engineering problems.	3
	PO 2	Identify and analyze complex engineering problems reaching substantiated conclusions using first principles of natural sciences, and engineering sciences to create a web page to produce specified outputs.	2
	PO 3	Develop and design solutions with interactive forms in different styles using javascript for complex engineering problems.	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 4	IUse research-based knowledge and research methods for analysis and interpretation of data, and synthesis of the information to provide valid conclusions using interactive forms with different styles using javascript, CSS and bind data using AJAX.	2
	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
CO 3	PO 3	Develop and design solutions with interactive forms in different styles using javascript for complex engineering problems.	2
	PO 4	Use research-based knowledge and research methods for analysis and interpretation of data, and synthesis of the information to provide valid conclusions using interactive forms with different styles using javascript, CSS and bind data using AJAX.	1
	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
CO 4	PO 2	Identify and analyze complex engineering problems reaching substantiated conclusions using first principles of natural sciences, and engineering sciences to create a web page to produce specified outputs.	2
	PO 3	Design solutions using web pages for complex engineering problems and design system components that meet the specified needs with appropriate consideration for the societal, and environmental considerations.	1
	PO 4	Use research-based knowledge and research methods for analysis and interpretation of data, and synthesis of the information to provide valid conclusions using interactive forms with different styles using javascript, CSS and bind data using AJAX.	2
	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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 12	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to produce specified outputs using web pages as per the requirements of the clients for different applications.	1
	PSO 3	Make use of computational and experimental tools for building career paths towards innovation startups, employability and higher studies.	2
CO 5	PO 1	Apply the knowledge of science, engineering fundamentals, and an engineering specialization to create a web page to produce specified outputs to the solutions of complex engineering problems.	3
	PO 2	Identify and analyze complex engineering problems reaching substantiated conclusions using first principles of natural sciences, and engineering sciences to create a web page to produce specified outputs.	2
	PO 3	Design solutions using web pages for complex engineering problems and design system components that meet the specified needs with appropriate consideration for the societal, and environmental considerations.	2
	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
	PO 10	Communication, Communicate effectively on complex engineering activities with the help of write effective reports and design documentation.	3
	PO 12	Recognize the need for life-long learning in the broadest context of technological change to extend the features and deployment of applications for solving problems that require interaction with a web server.	1
	PSO 3	Design solutions using web pages for complex engineering problems and design system components that meet the specified needs with appropriate consideration for the societal, and environmental considerations	2
CO 6	PO 1	Apply the knowledge of science, engineering fundamentals, and an engineering specialization to create a web page to produce specified outputs to the solutions of complex engineering problems.	3

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 2	Identify and analyze complex engineering problems reaching substantiated conclusions using first principles of natural sciences, and engineering sciences to create a web page to produce specified outputs.	2
	PO 3	Design solutions using web pages for complex engineering problems and design system components that meet the specified needs with appropriate consideration for the societal, and environmental considerations.	2
	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
	PO 8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	3
	PO 10	Communication, Communicate effectively on complex engineering activities with the help of write effective reports and design documentation.	3
	PO 12	Recognize the need for life-long learning in the broadest context of technological change to extend the features and deployment of applications for solving problems that require interaction with a web server.	1
	PSO 3	Design solutions using web pages for complex engineering problems and design system components that meet the specified needs with appropriate consideration for the societal, and environmental considerations	2

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

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	100	50	-	100	-	-	-	-	-	-	-	-	-	-
CO 2	100	66.6	40	55	100	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	30	55	100	-	-	-	-	-	-	-	-	-	-
CO 4	-	66.6	30	55	100	-	-	-	-	-	-	33	-	-	100
CO 5	100	66.6	40	-	100	-	-	-	-	60	-	33	-	-	100
CO 6	100	66.6	40	-	100	-	-	100	-	60	-	33	-	-	100

28 . COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

2 - 40 % <C < 60% –Moderate

1-5 <C$\leq$ 40% – Low/ Slight

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

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

29. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

30. ASSESSMENT METHODOLOGY INDIRECT:

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

31. RELEVANCE TO SUSTAINABILITY GOALS

Write brief description about the course and how its relevance to SDGs.

X	NO POVERTY	
X	ZERO HUNGER	
X	GOOD HEALTH AND WELL-BEING	
✓	QUALITY EDUCATION	**Quality Education:** Apps with good quality content can bring about significant cognitive development and motivate students to become more diligent in the process.
X	GENDER EQUALITY	
X	CLEAN WATER AND SANITATION	
X	AFFORDABLE AND CLEAN ENERGY	
X	DECENT WORK AND ECONOMIC GROWTH	

✓	INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Industry, Innovation, and Infrastructure:** Web and Mobile application development fundamentals are crucial for developing and maintaining Web application and technological innovations. It contribute to designing safer, more durable, and user friendly projects.
X	REDUCED INEQUALITIES	
X	SUSTAINABLE CITIES AND COMMUNITIES	
X	RESPONSIBLE CONSUMPTION AND PRODUCTION	
✓	CLIMATE ACTION	**Climate Action:** Students can create climate-related applications, such as carbon footprint calculators or climate data analysis tools, using Java script. This directly contributes to SDG 13 by raising awareness and facilitating climate action.
X	LIFE BELOW WATER	
X	LIFE ON LAND	
✓	PEACE, JUSTICE AND STRONG INSTITUTIONS	**Peace, Justice, and Strong Institutions:** Web and Mobile application skills can be applied to create tools for transparency, accountability, and data security. By focusing on ethical coding practices, the lab can contribute to strong and just institutions.

✓	PARTNERSHIPS FOR THE GOALS	**Partnerships for the Goals:** Collaborative projects can foster partnerships among students, educators, and local communities. These partnerships enhance knowledge sharing and the development of innovative solutions that align with multiple SDGs.

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD,ME**
Dr.D.Durga Bhavani, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**MECHANICAL ENGINEERING**				
2	Course Title	**PROBABILITY AND STATISTICS**				
3	Course Code	AHSD11				
4	Program	B.Tech				
5	Semester	III				
6	Regulation	BT-23				
7	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	1	4	-	-
8	Type of course (**Tick type of course**)	Core	Professional Elective	Open Elective	VAC	MOOCs
		✓	×	×	×	×
9	Course Offered	Odd Semester ✓		Even Semester ×		
10	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: 48 hours		Tutorials: 16 hours		Practical: 0 hours	
11	Course Co ordinator	Dr. G SRINIVASU				
	Course Instructor	Mr.SATYANARAYANA G				
12	Date Approved by BOS	23/08/2023				
13	Course Webpage	www.iare.ac.in/—-/—-				
14	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**	
		B.Tech	AHSD02	I	Matrices and Calculus	
		B.Tech	AHSD08	II	Differential Equations Vector Calculus	

15. Course Overview

Probability theory is the branch of mathematics that deals with modelling uncertainty. The course includes: random variables, probability distributions, hypothesis testing, confidence interval and linear regression. The use of probability models and statistical methods is for analyzing data, designing, manufacturing a product and the observed class frequencies for engineering and sciences.

16. COURSE OBJECTIVES:

The students will try to learn:

I	The theory of probability, conditional probability, Bayes theorem and their applications.
II	The theory of random variables, basic random variate distributions and their applications.
III	The role of Binomial, Poisson and Normal distributions in solving the real-life problems.
IV	The methods and techniques for quantifying the degree of closeness among two or more variables by using coefficient of correlation and the concept of linear regression analysis.
V	The Estimation theory and hypothesis testing in statistics play a vital role in the assessment of the quality of the materials, products and ensuring the standards of the engineering process.

17. COURSE OUTCOMES:

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

CO 1	**Explain** the axioms of the probability, conditional probability and by using these concepts, establish the elementary theorems on probability. Explain the role of Bayes theorem in solving the typical uncertain problems in probability.	Understand
CO 2	**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 3	**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 4	**Apply** Bivariate Regression as well as Correlation Analysis for statistical forecasting.	Apply
CO 5	**Identify** the role of statistical hypotheses, types of errors, confidence intervals, the tests of hypotheses for large samples in making decisions over statistical claims in hypothesis testing	Apply
CO 6	**Identify** the tests of hypothesis for small samples in making decisions over statistical claims in hypothesis testing	Apply

18. Topic Learning Outcome (TLOs):

S No	**TOPIC NAME**	**TLO No**	**Topic Learning Outcome's**	**Course Out-come**	Blooms Level
1	Classical definition of probability	TLO 1	**Summarize** basic fundamentals of probability through a procedural approach.	CO 1	Understand
2	Axiomatic Approach of probability	TLO 2	**Define** axioms of probability to obtain the solution of problems in probability.	CO 1	Apply
		TLO 3	**Use** the axioms of probability to solve the problems.	CO 1	Apply

S No	TOPIC NAME	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
3	Elementary theorems on probability	TLO 4	**Utilize** axioms of probability to prove the elementary theorems on probability	CO 1	Apply
		TLO 5	**Determine** the solution for problems related to probability	CO 1	Understand
4	Bayes Theorem	TLO 6	**Apply** Bayes Theorem for finding the solution of problems related to probability.	CO 1	Apply
5	Random Variables	TLO 7	**Distinguish** Discrete and Continuous Random Variables	CO 2	Understand
6	Probability mass function and Probability density function	TLO 8	**Define** the probability mass function and Probability density function.	CO 2	Understand
		TLO 9	**Utilize** the concept of random variables to obtain the solution of related problems.	CO 2	Apply
7	Binomial Distribution	TLO 10	**Define** the probability distribution of Binomial distribution.	CO 3	Understand
		TLO 11	**Interpret** Mean and Variance of binomial distribution.	CO3	Understand
		TLO 12	**Solve** the problems by using Binomial Distribution.	CO 3	Apply
8	Poisson Distribution	TLO 13	**Interpret** Poisson distribution as a limiting case of Binomial distribution.	CO 3	Understand
		TLO 14	**Interpret** Mean and Variance of poisson distribution.	CO3	Understand
		TLO 15	**Solve** the problems by using Poisson Distribution.	CO 3	Apply
9	Normal Distribution	TLO 16	**Define** the probability density function of Normal distribution.	CO 3	Understand
		TLO 17	**Interpret** Mean, Variance and Mode of normal distribution.	CO3	Understand
		TLO 18	**Solve** the problems by using Normal Distribution.	CO 3	Apply
9	Correlation	TLO 19	**Define** the correlation coefficient and Formulate the Karl-Pearson's Coefficient of correlation to solve some problems for the given data	CO 4	Understand

S No	TOPIC NAME	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
		TLO 20	**formulate** Rank correlation coefficient to solve the problems for the given data.	CO 4	Apply
10	Regression Lines	TLO 21	**Formulate** the regression lines of y on x and x on y to solve some problems.	CO 4	Understand
		TLO 22	**Find** the angle between two regression lines and using this formulae determine the solution of some problems.	CO 4	Apply
11	Test of Hypothesis	TLO 23	**Test** of significance for single mean and difference of means for large samples with suitable examples.	CO 5	Apply
		TLO 24	**Test** of significance for single proportion and difference of proportions for large samples with suitable examples.	CO 5	Apply
		TLO 25	**Explain** t-distribution, F-distribution and Chi-square distribution with suitable examples.	CO 6	Apply

19. Employability Skills

Probability: Employability/ Skill development: Uses the basics of theory of probability in the field of engineering.
Statistics: Employability/ Skill development: Uses the concept of the testing of hypothesis in engineering problems

20. Content Delivery / Instructional Methologies:

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

21. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Semester End Examination (SEE): The SEE is conducted for 60 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. No choice is given from first two modules. Each question carries 12 marks. There could be a maximum of two sub divisions in a question

Table 4: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	CIA - I	CIA - II	SEE	Total Marks
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	40 Marks
Total	-	-	**100 Marks**	

22. Course content - Number of modules: Five:

MODULE I	**PROBABILITY** ‘ | **Number of Lectures: 10**
	Probability, axiomatic approach, elementary theorems on probability, conditional probability, multiplication theorem, Bayes theorem (without proof).
MODULE II	**RANDOM VARIABLES** | **Number of Lectures: 09**
	Random variables: Discrete and continuous random variables, probability distribution, probability mass function and probability density function.
MODULE III	**PROBABILITY DISTRIBUTIONS** |**Number of Lectures: 10**
	Binomial distribution: Mean and variance of Binomial distribution, Poisson distribution: Poisson distribution as a limiting case of Binomial distribution, Mean and variance of Poisson distribution, Normal distribution: mean, variance, mode, median of normal distribution.
MODULE IV	**CORRELATION AND REGRESSION** | **Number of Lectures: 09**
	Correlation- Karl Pearson's coefficient of correlation, rank correlation, repeated ranks, Regression: Lines of reghression, regression coefficient, angle between two regression lines.
MODULE V	**TEST OF HYPOTHESIS** | **Number of Lectures: 10**
	Population, sample, standard error; test of significance: Null hypothesis, alternate hypothesis. Types of errors, level of significance. Large sample tests: Test of hypothesis for single mean, difference between means, single proportion and difference between proportions. Small sample tests: Student's t- distribution, F-distribution and chi-square distribution. .

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.

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.

MATERIALS ONLINE:

1. Course template
2. Tutorial question bank
3. Definition and terminology
4. Tech-talk topics
5. Assignments
6. Model question paper-I
7. Model question paper-II
8. Lecture notes
9. Early learning readiness videos (ELRV)
10. Power point presentations

ELECTRONIC RESOURCES:

1. http://e4uhu.com/down/Applied/9th
2. https://toaz.info/32fa2f50-8490-42cf-9e6a-f50cb7ea9a5b
3. http://www.mathworld.wolfram.com

23. COURSE PLAN:

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

S.No	Topics to be covered	CO’s	Reference
Discussion on OBE			
1	**Discussion on Outcome Based Education, CO, POs and PSOs**		
CONTENT DELIVERY (THEORY)			
1	Probability Basic definitions	CO 1	T2:26.3
2	Probability	CO 1	R2:21.48
3	Axioms of Probability	CO 1	T2:26.6 R2:21.50
4	Elementary theorems on Probability	CO 1	T2:26.6 R2:21.50

S.No	Topics to be covered	CO's	Reference
5	Conditional Probability	CO 1	T2:26.7 R2:21.51
6	Multiplication theorem	CO 1	T2:26.7 R2:21.51
7	Bayes theorem	CO 1	T2:26.7 R2:21.51
8	Discrete random variables	CO 2	T2:26.10
9	Continuous random variables	CO 2	T2:26.10
10	Probability distribution	CO 2	T2:26.14 R2:21.55
11	Probability mass function	CO 2	T2:26.15 R2:21.58
12	Probability Density Function	CO 2	T2:26.16 R2:21.61
13	Mathematical Expectation	CO 2	T2:25.12 R2:21.24
14	Binomial Distribution	CO 3	T2:25.16 R2:21.29
15	Mean and Variance of Binomial Distribution	CO 3	T2:25.14 R2:21.31
16	Expected Frequency of Binomial Distribution	CO 3	T2:25.14 R2:21.33
17	Poisson Distribution as a limiting case of binomial distribution	CO 3	R2:21.33
18	Mean and Variance of Poisson distribution	CO 3	T2:27.2 R2:21.64
19	Expected Frequency of Poisson Distribution	CO 3	T2:27.2
20	Normal distribution – I	CO 3	T2:27.2 R2:21.67
21	Mean and Variance of Normal Distribution	CO 3	T2:27.2
22	Mode and Median of Normal distribution	CO 3	T2:27.3 R2:21.71
23	Normal distribution – II	CO 3	T2:27.4 R2:21.68
24	Correlation	CO 4	T2:27.7 R2:21.74
25	Karl-Pearson's coefficient of Correlation	CO 4	T2:27.7 R2:21.74
26	Rank Correlation	CO 4	T2:27.12 R2:21.75

S.No	Topics to be covered	CO's	Reference
27	Rank Correlation for Repeated Ranks	CO 4	T2:27.8 R2:21.72
28	Regression Lines	CO 4	T2:27.8 R2:21.73
29	Regression coefficients	CO 4	T2:27.14 R2:21.78
30	Angle between two regression Lines	CO 4	T2:27.19 R2:21.814
31	Sampling distribution - Population, sample, standard error	CO 5	T2:27.12 R2:21.82
32	Test of significance: Null hypothesis, Alternate hypothesis, types of errors, level of significance	CO 5	T2:26.15 R2:21.58
33	Testing of hypothesis for Large Samples	CO 5	T2:26.15 R2:21.58
34	Test of hypothesis for single mean	CO 5	T2:26.16 R2:21.61
35	Test of hypothesis for difference of means	CO 5	T2:25.14 R2:21.33
36	Test of hypothesis for single proportion	CO 5	R2:21.33
37	Test of hypothesis for difference of proportions	CO 5	T2:27.2 R2:21.64
38	Testing of hypothesis for small samples	CO 6	T2:27.2
39	Student's t-distribution for single mean	CO 6	T2:26.16 R2:21.61
40	Student's t-distribution for difference of means	CO 6	T2:25.12 R2:21.24
41	F-distribution	CO 6	T2:25.16 R2:21.29
42	Chi-Square distribution – I	CO 6	T2:27.14 R2:21.78
43	Chi-Square distribution – II	CO 6	T2:27.12 R2:21.82
PROBLEM SOLVING/ CASE STUDIES			
44	Problems on Probability	CO 1	T2:26.3
45	Problems on Discrete and Continuous random variables	CO 1	R2:21.48
46	Problems on Probability mass function	CO 1	T2:26.6 R2:21.50
47	Problems on Probability density function	CO 1	T2:26.7 R2:21.51
48	Problems on Binomial Distribution	CO 2	T2:26.8
49	Problems on Poisson Distribution	CO 2	T2:26.10

S.No	Topics to be covered	CO's	Reference
50	Problems on Normal Distribution	CO 2	T2:26.14 R2:21.55
51	Problems on Correlation	CO 3	T2:26.15 R2:21.58
52	Problems on Regression	CO 4	T2:26.16 R2:21.61
53	Problems on Sampling distribution	CO 5	T2:25.12 R2:21.24
54	Problems on Test of hypothesis for single mean and difference of means	CO 5	T2:25.16 R2:21.29
55	Problems on Test of hypothesis for single proportion and difference of proportions	CO 6	T2:25.14 R2:21.31
56	Problems on t-distribution	CO 6	T2:25.14 R2:21.33
57	Problems on F-distribution	CO 6	R2:21.33
58	Problems on Chi-Square distribution	CO 6	T2:27.2 R2:21.64
DISCUSSION OF DEFINITION AND TERMINOLOGY			
59	Definitions terminology discussion on probability and random variables	CO 1	T2:26.6 R2:21.50
60	Probability and Random variables	CO 2	T2:26.7 R2:21.51
61	Definitions& terminology discussion on correlation and regression.	CO 3, CO 4	T2:25.14 R2:21.33
62	Definitions & terminology discussion on Tests of Hypothesis.	CO 5	R2:21.33
63	Definitions & terminology discussion on Tests of significance.	CO 6	R2:21.33
DISCUSSION OF QUESTION BANK			
64	Question bank discussion on Probability, Random variables and Probability Distributions	CO 1	T2:26.6 R2:21.50
65	Question bank discussion on probability distributions.	CO 2	T2:26.7 R2:21.51
66	Question bank discussion on correlation and regression.	CO 3,CO 4	T2:25.14 R2:21.33
67	Question bank discussion on Tests of Hypothesis.	CO 5	R2:21.33
68	Question bank discussion on Tests of significance.	CO 6	R2:21.33

24. PROGRAM OUTCOMES & PROGRAM SPECIFIC 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
Program Specific Outcomes	
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.

25. 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

26. 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

27. 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	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-

28. 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	Determine the solution of complex engineering problems by using Axiomatic approach and elementary theorems of Probability	2
	PO 2	Interpret the statement of Bayes Theorem and determine the solution of complex engineering problems related to probability	6
CO 2	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
CO 3	PO 1	Interpret the Probability distributions such as Binomial, Poisson and Normal distribution (Understanding) and appreciate their importance and applicability (Apply) in solving complex engineering problems involving uncertainty.	2
	PO 2	Apply the suitable formulae to find mean, variance, mode and median for the given distributions. Use area property to solve the problems in normal distribution.	6
CO 4	PO 1	Interpret Karl-Pearson's coefficient of correlation, rank correlation and rank correlation for repeated ranks for solving some real-time complex engineering problems governed by correlation with the knowledge of fundamental principles of mathematics.	2
	PO 2	Apply the standard Regression line equations for solving some complex engineering problems. Understand the angle between two regression lines and apply the formulae to solve some related problems.	6
CO 5	PO 1	Interpret population, sample, standard error, null hypothesis and alternate hypothesis.	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 2	Explain the types of errors and level of significance in hypothesis testing of complex engineering problems.	6
CO 6	PO 1	Explain the working principle to test the given hypothesis. Interpret the test of hypothesis for single mean, difference of means, single proportion and difference of proportions for large samples.	2
	PO 2	Apply t-distribution, F-distribution, Chi-square distribution to test the hypothesis for small samples.	6

29. 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	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-

30. 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	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.7	60	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.7	60	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.7	60	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.7	60	-	-	-	-	-	-	-	-	-	-	-	-	-

31. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

2 - 40 % $< C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

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

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

32. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory practices	-	Student Viva	-	Certification	-
Term Paper	-	Tech-talk / 5 Minutes Video	✓	Open Ended Experiments	-
Definitions and Terminology	✓	Quiz	✓	Assignments	✓

33. ASSESSMENT METHODOLOGY INDIRECT:

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

34. Relevance to Sustainability goals

Brief description about the course and how its relevance to SDGs.

Mathematics plays an important role in the achievement of the Sustainable Development Goals (SDG) and at the same time these allow working with real situations in the subject of mathematics, providing the student with active learning. Sustainability is used to make the student see the usefulness of mathematics while instilling values and attitudes towards it.

x	1		
x	2		

x	3	GOOD HEALTH AND WELL-BEING	
✓	4	QUALITY EDUCATION	**Quality Education:**This subject will improve the quality education in engineering and provides the knowledge in mathematical modelling which is used for real time applications
x	5	GENDER EQUALITY	
x	6	CLEAN WATER AND SANITATION	
x	7	AFFORDABLE AND CLEAN ENERGY	
x	8	DECENT WORK AND ECONOMIC GROWTH	
x	9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	
x	10	REDUCED INEQUALITIES	
x	11	SUSTAINABLE CITIES AND COMMUNITIES	
x	12	RESPONSIBLE CONSUMPTION AND PRODUCTION	

x	13		
x	14		
x	15		
x	16		
x	17		

Approved by: Board of Studies in the meeting conducted on 23/08/2023

Signature of Course Coordinator **HOD**
Dr. G. Srinivasu, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

<table>
<tr><td>1</td><td>Department</td><td colspan="5">MECHANICAL ENGINEERING</td></tr>
<tr><td>2</td><td>Course Title</td><td colspan="5">SOLID MECHANICS AND MATERIALS</td></tr>
<tr><td>3</td><td>Course Code</td><td colspan="5">AMED06</td></tr>
<tr><td>4</td><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>5</td><td>Semester</td><td colspan="5">III Semester</td></tr>
<tr><td>6</td><td>Regulation</td><td colspan="5">BT-23</td></tr>
<tr><td rowspan="3">7</td><td rowspan="3">Structure of the course</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Lab</td><td>Credits</td></tr>
<tr><td>3</td><td>0</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td rowspan="2">8</td><td rowspan="2">Type of course
(Tick type of course)</td><td>Core</td><td>Professional Elective</td><td>Open Elective</td><td>VAC</td><td>MOOCs</td></tr>
<tr><td>✓</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>9</td><td>Course Offered</td><td colspan="2">Odd Semester ✓</td><td colspan="3">Even Semester ×</td></tr>
<tr><td rowspan="2">10</td><td colspan="6">Total lecture, tutorial and practical hours for this course
(16 weeks of teaching per semester)</td></tr>
<tr><td colspan="2">Lectures: .... hours</td><td colspan="2">Tutorials: .... hours</td><td colspan="2">Practical: .... hours</td></tr>
<tr><td>11</td><td>Course Coordinator</td><td colspan="5">Dr. K. Ch Apparao</td></tr>
<tr><td>12</td><td>Date Approved by BOS</td><td colspan="5">12/08/2024</td></tr>
<tr><td>13</td><td>Course Webpage</td><td colspan="5">www.iare.ac.in/—-/—-</td></tr>
<tr><td rowspan="2">14</td><td rowspan="2">Course Prerequistes</td><td>Level</td><td>Course Code</td><td>Semester</td><td colspan="2">Prerequisites</td></tr>
<tr><td>B.Tech</td><td>AMED04</td><td>II</td><td colspan="2">Engineering Mechanics</td></tr>
</table>

15. Course Overview

this course provide students an understanding of Structure of materials and their properties, deformation of rigid bodies under static loading conditions. It covers the concepts of engineering mechanics of materials and the behavior of the materials and components under applied loads. The purpose of the course is application of strength of materials concepts with respect to mechanical engineering design and analysis.

16. COURSE OBJECTIVES:

The students will try to learn:

I	The fundamental knowledge of crystallography and properties of ferrous and non ferrous metals.
II	The variations of normal and shear stresses, slope and deflections throughout the span and cross section of solids in relation to the applied loads.
III	The concepts of stress analysis, theories of failure, relationship between mechanical and metallurgical properties to design and analyse commonly used machine components.

17. 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	Remember
CO 2	**Identify** the atomic packing factor of unit cells of various crystal structures to study the properties of materials.	Apply
CO 3	**3 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 4	**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 5	**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 6	**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

18. Topic Learning Outcome (TLOs):

S.No	Topic(s)	TLO No	Topic Learning Outcome's	Course Outcome	Blooms Level
1	Introduction to Materials	1	**Explain** the fundamental steps involved in the materials engineering through a procedural approach	CO 1	Remember
		2	**Outline** the advantages and limitations of various materials for producing complex shapes	CO 1	Remember
		3	**Interpret** the role of light weight materials in current automobile sector	CO 1	Remember

S.No	Topic(s)	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
		4	**Summarize** the impact of selection of material on the quality of the final product	CO 1	Remember
2	crystal structure and grain size	5	**Examine** the significance of bonding for understanding atomic and molecular bonding and variety.	CO 1	Remember
		6	**calculate** the unit cells and volumetric, planar and linear density values in unit cell.	CO 1	Remember
3	Mechanical properties of materials	7	**Explain** stracture and properties of non ferrous materials like Al, Cu and Titanium	CO 1	Remember
		8	**Classify** and Distinguish different types of cast irons, steels	CO 1	Remember
6	Recrystallization and Grain Growth	14	**Understand** importance of star delta transfformation solving complex problems within the classroom and outside world	CO 2	Understand
5	Elasticity and plasticity	11	**Understand** of basics concept ofstress and strain.	CO 3	Understand
		12	**Understand** importance of stress strain diagram to understand the strength of material	CO 3	Understand
		13	**Apply** stress strain diagram for different materials	CO 3	Apply
6	Working stress and Factor of safety	14	**Understand** the concept of working stress to estimate the Factor of safety	CO 3	Understand
7	Elastic modulus	15	**Apply** the formulas and find factor of safety	CO 3	Apply
8	Bars of varying section – composite bars	16	**Understand** the concept Apply the formula for different loads	CO 3	Apply
9	Temperature stresses	17	**Evaluate** the temperature stresses for varying cross sections	CO 3	Understand
10	Strain energy – Resilience	17	**Understand** the concept and Apply the formula for different loads	CO 3	Understand
11	Concept of shear force and bending moment	19	**Understand** Apply S.F and B.M concept on cantilever beam with point load	CO 4	Apply

S.No	Topic(s)	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
12	S.F and B.M diagrams for cantilever beam	20	**Understand** the concept SFD and BMD (B2) and apply S.F and B.M concept on cantilever beam with UDL and UVL	CO 4	Apply
13	S.F and B.M diagrams for simply supported beam subjected to point load	21	**Understand** Understanding concept SFD and BMD (B2) and Apply S.F and B.M concept on simply supported beam with UDL and UVL	CO 5	Apply
14	S.F and B.M diagramsfor overhanging beam	22	**Understand** Understanding concept SFD and BMD (B2) and Apply S.F and B.M concept on overhanging beam with UDL and UVL	CO 5	Apply
15	Theory of simple bending	23	**Understand** the concept of Pure bending to determine bending stresses	CO 5	Understand
16	Determination bending stresses-sectionmodulus	24	**Analyze** the bending stress and sectionmodulus of rectangular and circularsections	CO 6	analyze
17	Shear stress distribution across various beams	25	**Apply** Apply Shear stress distribution concept on rectangular, circular sections	CO 6	Understand
18	Determination bending stresses – I and T Sections	26	**Understaand** the concept of Pure bending to Evaluate the bending stress I and T Sections	CO 6	Understand

19. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
From maintaining power infrastructure to developing navigation and communications systems, electrical engineers play crucial roles across nearly every industry. With advanced electrical engineering skills, experts can lead the design, testing and manufacturing of the equipment that keep the world running.

20. Content Delivery / Instructional Methologies:

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

21. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Table 4: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	CIA - I	CIA - II	SEE	Total Marks
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

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 12 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

22. Course content - Number of modules: Five:

MODULE I	**STRUCTURE OF SOLIDS** | **Number of Lectures: 09**
	Structure of crystalline solids: Atomic structure and 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	**ENGINEERING MATERIALS** | **Number of Lectures: 09**
	Engineering Materials: Cast Irons, Structure and properties of White cast iron, malleable cast iron, grey cast iron. Non-ferrous metals and alloys, structure and properties of Aluminum Copper and its alloys, titanium and its alloys.
MODULE III	**SIMPLE STRESSES AND STRAINS** | **Number of Lectures: 10**
	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 IV	**SHEAR FORCE AND BENDING MOMENT DIAGRAMS | Number of Lectures: 09**
	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 V	**PRINCIPAL STRESSES AND TORSION | Number of Lectures: 08**
	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. Theory of pure torsion, derivation of torsion equations , assumptions made in the theory of pure torsion, torsional moment of resistance, polar section modulus

TEXTBOOKS

1. Sidney H Avner,, "*Introduction to Physical Metallurgy*", McGraw-Hill Education, 2nd Edition, 2008.
2. S. Ramamrutam, "*Strength of Materials*", Dhanpat Rai Publishing Company, 18th Edition, 2014.

REFERENCE BOOKS:

1. Kodgire, "*Material Science and Metallurgy*", Everst Publishing House, 12th Edition, 2002.
2. V Raghavan, "*Elements of Material Science*", PHI Learning Company Pvt Ltd, 6th Edition, 2015.
3. R.Subramaniam, "*The Strength of Materials*", Oxford publishers, 4th Edition,2018.

MATERIALS ONLINE:

1. https://www.nptel.ac.in/courses/112106286
2. https://www.akanksha.iare.ac.in
3. http://www.efunda.com/sm home/sm.cfm
4. https://nptel.ac.in/courses/112105171/1

23. 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		

S.No	Topics to be covered	CO's	Reference
CONTENT DELIVERY (THEORY)			
1	Introduction to Atomic structure	CO 1	T1: 2.1
2	bonding in solids	CO 1	T1:2.4
3	Unit cell, Space lattices	CO 1	T1:2.4
4	Crystal structures and its types	CO 1	T1:2.5
5	Calculations of radius	CO 1	T1: 2.1
6	Coordination Number for different cubic structures	CO 1	T1:2.4
7	Atomic Packing Factor for different cubic structures	CO 1	T1:2.4
8	Indices for planes	CO 2	T1:1.5- 1.6
9	Imperfection in solids, point defects	CO 2	T1:1.8- 1.12
10	Indices for planes and directions	CO 1	T1: 2.1
11	Imperfection in solids, point defects	CO 1	T1:1.13- 1.18
12	Line defects	CO 1	T1:1.1- 1.18
13	Planar defects	CO 2	T1:5.1- 5.2
14	Line defects and Planar defects	CO 1	T1:5.3
15	Structure and properties of cast iron	CO 2	T1:5.7
16	Structure and properties of White cast iron,	CO 2	T1:5.4- 5.6
17	Structure and properties of malleable cast iron	CO 2	T1:6.5- 6.11
18	Structure and properties of grey cast iron	CO 3	T1:7.1-7.4
19	Non-ferrous metals and alloys	CO 3	T1:5.3
20	Structure and properties of Aluminum	CO 3	T1:5.7
21	Structure and properties of Aluminum and its alloys	CO 3	T1:5.1- 5.2
22	Structure and properties of titanium	CO 3	T1:5.3
23	Structure and properties of titanium and its alloys	CO 2	T1:5.7
24	structure and properties of Copper	CO 3	T1:5.4- 5.6
25	structure and properties of Copper and its alloys	CO 2	T1:6.5- 6.11
26	Elasticity and plasticity	CO 3	T1:7.1-7.4
27	Types of stresses and strains, Hooke's law	CO 3	T1:8.4- 8.6
28	Stress - strain diagram for mild steel	CO 3	T1: 8.12-8.15
29	Working stress, factor of safety, lateral strain	CO 3	T1:8.4- 8.6
30	Poisson's ratio and volumetric strain	CO 4	T1: 8.12-8.15
31	Elastic moduli and the relationship between them	CO 4	T1:8.4- 8.6
32	Bars of varying section, composite bars, stresses.	CO 3	T1: 8.12-8.15
33	Definition of beam, types of beams.	CO 4	T1:8.4- 8.6
34	concept of shear force and bending moment	CO 5	T1: 8.12-8.15
35	Shear force and bending moment diagram for cantilever	CO 5	T1:8.4- 8.6
36	Simply supported beam subjected to point loads, U.D.L.,	CO 5	T1: 8.12-8.15
37	Simply supported beam subjected to point loads, U.D.L., U.V.L. and combination of these loads	CO 5	T1:8.4- 8.6
38	Simply supported beam subjected to various types of loads	CO 6	T1: 8.12-8.15
39	Principle stresses and strains	CO 6	T1:8.4- 8.6

S.No	Topics to be covered	CO's	Reference
40	Computation of principal stresses and strains on inclined planes.	CO 6	T1:8.12-8.15
PROBLEM SOLVING/ CASE STUDIES			
1	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	T1:10.8
2	Classify stainless steels and mention their properties and applications.	CO 2	T1:10.9- 10
3	Explain heat treatable aluminium alloys and give applications	CO 2	T4:10.10
4	Atomic Packing Factor for different cubic structures	CO 2	T1:8.2
5	Indices for planes and directions	CO 3	T1:1.1
6	Stress - strain diagram for mild steel	CO 3	T1:1.5- 1.6
7	Working stress, factor of safety, lateral strain	CO 3	T1:1.8- 1.12
8	Poisson's ratio and volumetric strain	CO 3	T1:1.13- 1.18
9	Bars of varying section, composite bars, temperature stresses.	CO 3	T1:1.19.1-1.19.2
10	Simply supported beam subjected to point loads, U.D.L., U.V.L. and combination of these loads	CO 3	T1:1.19.1-1.19.2
11	Overhanging beams subjected to point loads, U.D.L., U.V.L. and combination of these loads	CO 4	T1:1.193
12	Point of contra flexure, relation between S.F., B.M, and rate of loading at a section of a beam.	CO 4	T1:1.19.6
13	Computation of principal stresses and strains on inclined planes.	CO 5	T1:1.19.
14	Mohr's circle: Uni axial problems, Bi axial problems.	CO 5	T1:2.11.1
15	Shear stress distribution,	CO 5	T1:2.11.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Structure of crystalline solids	CO 1	T2:2.1
2	Engineering Material	CO 2	T2:3.1
3	Simple stresses and strains	CO 3,4	T1:5.1
4	Shear force and Bending moment diagrams	CO 5	T1:7.1
5	Principal stresses and strains	CO 6	T1: 11.12
DISCUSSION OF TUTORIAL QUESTION BANK			
1	Structure of crystalline solids	CO 1	T2:2.1
2	Engineering Material	CO 2	T2:3.1
3	Simple stresses and strains	CO 3,4	T1:5.1
4	Shear force and Bending moment diagrams	CO 5	T1:7.1
5	Principal stresses and strains	CO 6	T1: 11.12

24. PROGRAM OUTCOMES & PROGRAM SPECIFIC 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
Program Specific Outcomes	
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..

Program Outcomes	
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 creating innovative career paths, to be an entrepreneur and desire for higher studiesr.

25. 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	Assignments

26. 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	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

27. 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	✓	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	-

28. 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**	4
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**.	5
CO 3	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
	PSO 1	**Formulate and evaluate** engineering concepts of principal stresses and strains adopting the Mohrs circle for the resolution of engineering components such as shafts.	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 4	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.	4
	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 5	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
	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 6	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 variety of beam sections with proper **validation** and safety.	5

COURSE OUTCOMES	PO'S / PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PSO 1	**Make use of** computational and experimental tools for building career paths towards **innovation**, startups, employability in the field of structural engineering.	2

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

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	66.7	50	-	-	-	-	-	-	-	-	-	-	-		-
CO 3	66.7	60	30	-	-	-	-	-	-	-	-	-	66.7	-	-
CO 4	66.7	50	50	40	-	-	-	-	-	-	-	-	66.7	-	-
CO 5	66.7	50	-	-	-	-	-	-	-	-	-	-	66.7	-	-
CO 6	100	60	50	-	-	-	-	-	-	-	-	-	66.7	-	-

31. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

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

32. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓	Quiz	✓		

33. ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback
✓	Early Semester Feedback	✓	Assessment of activities/ Modeling & Experimental Tools in Engineering by Experts

34. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1		
2		

3	GOOD HEALTH AND WELL-BEING	
4	QUALITY EDUCATION	**Quality Education:** This subject will improve the quality education in engineers and gives the awareness in manufacturing process usage in day-to-day life.
5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	
7	AFFORDABLE AND CLEAN ENERGY	**Affordable and Clean Energy:** Achieving affordable and clean energy in manufacturing involves using energy-efficient equipment, integrating renewable energy sources like solar and wind, optimizing processes through smart technologies, and adopting sustainable practices such as waste heat recovery and circular economy models. Collaboration with industry partners and leveraging government incentives can further support these initiatives.
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Industry, Innovation, and Infrastructure: :** Industry innovation and infrastructure in manufacturing focus on integrating advanced technologies like IoT, AI, and robotics to enhance efficiency and productivity. Upgrading infrastructure to support smart manufacturing and adopting sustainable practices ensure resilience and environmental sustainability. Collaboration with research institutions and investment in cutting-edge technology drive continuous improvement and competitiveness.

10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	**Responsible Consumption and Production** Responsible consumption and production in manufacturing involve minimizing waste through efficient resource use and recycling, adopting sustainable materials, and reducing environmental impact. Implementing circular economy practices ensures products are designed for longevity and recyclability. Monitoring and optimizing supply chains enhance sustainability, while transparent reporting promotes accountability
13	CLIMATE ACTION	
14	LIFE BELOW WATER	
15	LIFE ON LAND	
16	PEACE, JUSTICE AND STRONG INSTITUTIONS	

17	PARTNERSHIPS FOR THE GOALS	

Approved by: Board of Studies in the meeting conducted on ——————————.

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

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**MECHANICAL ENGINEERING**				
2	Course Title	**ENGINEERING THERMODYNAMICS**				
3	Course Code	AMED07				
4	Program	B.Tech				
5	Semester	III Semester				
6	Regulation	BT-23				
7	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	0	3	2	1
8	Type of course (**Tick type of course**)	Core	Professional Elective	Open Elective	VAC	MOOCs
		✓	-	-	-	-
9	Course Offered	Odd Semester ✓		Even Semester ×		
10	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: .... hours		Tutorials: .... hours		Practical: .... hours	
11	Course Coordinator	Dr. G. Hima Bindu				
12	Date Approved by BOS	22/08/2023				
13	Course Webpage	www.iare.ac.in/—-/—-				
14	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**	
		B.Tech	AHS00	I	Engineering Physics	

15. 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 basedon 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.

16. COURSE OBJECTIVES:

The students will try to learn:

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

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

18. Topic Learning Outcome (TLOs):

S.No	**Topic(s)**	**TLO No**	**Topic Learning Outcome's**	**Course Out-come**	Blooms Level
1	Introduction to Engineering Thermodynamics	1	**Explain** the fundamental concepts of thermodynamics, including systems, properties, processes, and state.	CO 1	Understand
		2	**Aware** the Zeroth law of theermodynamics with in the class room	CO 1	Understand

S.No	Topic(s)	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
		3	**Identify** the principle of thermometer within the classroom as well as outside the classroom.	CO 1	Understand
		4	**Practice** Steady flow energy equation with in the class room	CO 1	Understand
3	First Law of Thermodynamics	5	**Apply** the first law of thermodynamics to closed and open systems. within the classroom and outside world	CO 1	Apply
		6	**Analyze** energy interactions and work-energy principles. within the classroom and outside world	CO 1	Analyze
4	Second Law of Thermodynamics	7	**Explain** the second law of thermodynamics and its implications. within the classroom.	CO 1	Understand
		8	**Define and apply** the concepts of entropy and reversibility. within the classroom	CO 1	Remember and Apply
5	Properties of Pure Substances	9	**Understand** the property tables and charts for pure substances. and be able to use the property tables	CO 1	Understand
		10	**Interpret** phase diagrams and thermodynamic property relations able to calculte problems	CO 2	Understand
6	Thermodynamic Cycles	11	**Evaluate** the performance of these cycles and their efficiencywithin the classroom and outside world.	CO 2	Evaluate
		12	**Analyze** various thermodynamic cycles including Carnot, Rankine, Otto, Diesel, and Brayton cycles. within the classroom and outside world	CO 2	Analyze
		13	**Understand** , Vander Waals equation within the classroom and outside world	CO 2	Understand
7	Heat Transfer	14	**Understand** the modes of heat transfer: conduction, convection, and radiation. within the classroom and outside world	CO 2	Understand
8	Psychrometry and Air Conditioning	15	**Explain** psychrometric processes and the use of psychrometric charts. within the classroom and outside world	CO 2	Understand
9	Exergy Analysis	16	**Perform** exergy analysis for thermodynamic systems to identify losses and inefficiencies.	CO 2	Create

S.No	Topic(s)	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
10	Real Gases and Mixtures	17	**Understand** the behavior of real gases and gas mixtures to solve different types of problems	CO 3	Understand
11	Applications in Engineering	17	**Use** thermodynamic principles in various engineering applications such as refrigeration, power generation, and engines.	CO 3	Understand
12	Problem-Solving Skills	19	**Develop** analytical and computational skills to solve thermodynamic problems.	CO 4	Apply
13	Critical Thinking and Innovation	20	**Encourage** critical thinking and innovative approaches oin solving thermodynamic challenges.	CO 4	Create
		21	**Able** awareness of the latest advancements and technologies in thermodynamics	CO 4	Understand
14	Sustainability and Environmental Impact	22	**Understand** the environmental impact of thermodynamic processes and systems in class room	CO 5	Understand
15	Sustainability and Environmental Impact	23	**Promote** sustainable practices and green technologies in thermodynamic applications	CO 5	Understand
16	Critical Thinking and Innovation	24	**Analyze** experimental data to draw meaningful conclusions in class room	CO 5	Analyze
17	Heat Transfe	25	**Apply** the principles of heat transfer to solve related engineering problems	CO 6	Apply
18	Psychrometry and Air Conditioning	26	**Analyze** air conditioning processes and systems in class room	CO 6	Analyze

19. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
Having Strong Foundation in Thermodynamic Principles, Energy Sector Insight, Environmental Awareness, good at Designing thermodynamic systems for maximum efficiency and performance and Understanding the thermal properties of different materials and their applications in various industries.Developing these skills can significantly enhance employability for various roles in engineering, research, and industry applications.

20. Content Delivery / Instructional Methologies:

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

21. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Table 4: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

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 12 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
35%	Understand
55%	Apply

22. Course content - Number of modules: Five:

MODULE I	**: BASIC CONCEPTS AND FIRST LAW OF THERMODYNAMICS . | Number of Lectures: 10**
	System, control volume, surrounding, boundaries, universe, types of systems, macroscopic and microscopic viewpoints, concept of continuum, thermodynamic equilibrium, state, property, process, cycle, reversibility, quasi static 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 | Number of Lectures: 09**
	Thermal reservoir, heat engine, heat pump, parameters of performance, second Law of thermodynamics, Kelvin Planck and Clausius statements and their equivalence, Corollaries, PMM of second kind, Carnot's principle, Carnot cycle and its specialties, thermodynamic scale of temperature, Clausius inequality, Entropy, principle of Entropy increase, availability and irreversibility, thermodynamic potentials, Gibbs and Helmholtz functions, Maxwell relations, Clapeyron equation, elementary treatment of the Third Law of thermodynamics.
MODULE III	**PURE SUBSTANCES and GAS LAWS . | Number of Lectures: 09**
	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 | Number of Lectures: 10**
	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, specificheats 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, vapour pressure, degree of saturation, adiabatic saturation, Carrier's equation, Psychometric chart.

MODULE V	**POWER CYCLES** . | **Number of Lectures: 09**
	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, 6 th edition, 2017.
2. Yunus Cengel, Michael A. Boles, "Thermodynamics-An Engineering Approach", Tata McGraw Hill, 8 th edition,2017. "*Network Analysis*", PHI, 3rd Edition, 2014.

REFERENCE BOOKS:

1. R.K. Rajput., "Engineering Thermodynamics", 4th edition, Laxmi Publications, 2016
2. Mahesh M Rathore., "Thermal Engineering", Tata McGraw Hill Publishers, 2013.
3. K. Ramakrishna, "Engineering Thermodynamics", Anuradha Publishers, 2 nd edition, 2011.
4. Holman. J.P, "Thermodynamics", Tata McGraw Hill, 4 th edition, 2013.

MATERIALS ONLINE:

1. https://nptel.ac.in/courses/101104063
2. https://www.coursera.org/learn/thermodynamics-intro
3. https://www.youtube.com/watch?v=FPaHNl7QQys
4. https://www.iare.ac.in

23. COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
	OBE DISCUSSION		
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping		
	CONTENT DELIVERY (THEORY)		
1	System, control volume, surrounding, boundaries, universe, types of systems.	CO 1	T2: 2.3
2	Macroscopic and microscopic viewpoints, concept of continuum	CO 1	R1:2.6
3	Thermodynamic equilibrium, state, property, process, cycle, reversibility.	CO 1	T1:2.6
4	Quasi static process, irreversible process, causes of irreversibility.	CO 1	T2:2.7

S.No	Topics to be covered	CO's	Reference
5	Various flow and non-flow processes ,energy in state and in transition, types-work	CO 1	T2: 2.22
6	Concept of quality of temperature,Principles of thermometry,reference points.	CO 1	T2:2.26
7	Heat,pointandpathfunction,Zerothlawof thermodynamics.	CO 1	T2:2.25
8	First law of thermodynamics, corollaries first law applied to a process	CO 2	T2:2.30
9	Applied to a flow system,steady flow energy equation.,	CO 2	T2:3.6 , R1: 4.39
10	Thermal reservoir,heat engine,heat pump	CO 1	T2: 3.14, R1: 4.31
11	Parametersofperformance,secondLawof thermodynamics	CO 2	T2:3.14, R1: 4.33
12	Kelvin Planck,Claussius statements and their equivalence	CO 2	R1:4.36
13	Corollaries,PMM of second kind, Carnot's principle	CO 2	T2:3.18 R1:4.64
14	Carnot cycle and its specialties	CO 2	T2:3.22
15	Thermodynamic scale of temperature, Claussius inequality	CO 2	T2:3.28 R1:4.67
16	Entropy,principle of Entropy increase, availability and irreversibilit	CO 2	T2:4.2
17	Thermodynamic potentials	CO 2	T2:4.3 R1:4.71
18	Gibbs and Helmholtz functions, Max well relations	CO 2	R2:4.68
19	Elementary treatment of the Third Law of thermodynamics	CO 3	T2:4.15 R1:5.74
20	Phase transformations,T-S and H-S diagrams, P-V-T surfaces,	CO 3	T1:4.12 R2:5.75
21	Triple point at critical state properties during change of phase,	CO 3	T1:4.8 R1:5.72
22	Dry ness fraction,Mollier charts,various thermodynamic processes	CO 3	T1:5.8 R1:5.73
23	Energy transfer,steam calorimeter	CO 3	T1:5.14 R1:6.78
24	Equation of state, specific and universal gas constants.	CO 4	T2:5.19 R1:6.81
25	Throttling and free expansion processes	CO 4	T1:6.4 R2:6.8
26	Deviations from perfect gas model,VanderWaals equation of state.	CO 4	T2:7.7 R1:7.74
27	Mole fraction, mass friction,gravimetric and volumetric analysis,volume fraction,	CO 4	T1:7.12 R2:8.75

S.No	Topics to be covered	CO's	Reference
28	Dalton's law of partial pressure, Avogadro's laws of additive volumes,and partial pressure	CO 4	T1:7.8 R1:8.72
29	Equivalent gas constant, internal energy,enthalpy, specific heats	CO 4	T1:8.8 R1:8.73
30	Entropy of mixture of perfect gases; psychometric properties	CO 4	T1:9.14 R1:10.78
31	Dry bulb temperature, wet bulb temperature,dew point temperature	CO 5	T2:9.19 R1:10.814
32	Thermodynamic wet bulb temperature, specific humidity,relative humidity,saturated air.	CO 5	T1:10.4 R2:11.68
33	Vapor pressure, degree of saturation, adiabatic saturation, Carrier's equation,Psychometric chart	CO 5	T2:10.7 R1:12.74
34	Otto,Diesel,Dual combustion cycles, Problems on cycles	CO 5	T1:11.12 R2:12.75
35	Description and representation on P-V and T-S diagram,	CO 5	T1:12.4 R2:13.68
36	Thermal efficiency, mean effective pressures on air standard basis.Comparison of cycles	CO 5	T2:13.7 R1:14.74
37	Energy transfer,steam calorimeter.	CO 5	T1:5.14 R1:6.78
38	Equation of state, specific and universal gas constants.	CO 5	T2:5.19 R1:6.81
39	Throttling and free expansion processes	CO 5	T1:6.4 R2:6.8
40	Deviations from perfect gas model, VanderWaals equation of state.	CO 5	T2:7.7 R1:7.74
PROBLEM SOLVING/ CASE STUDIES			
1	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
2	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

S.No	Topics to be covered	CO's	Reference
3	A piston cylinder device operates 1kg of fluid at 20atm pressure with initial volume is 0.04m3. Fluid is allowed to expand reversibly following pV1.45=C. So that the volume becomes double.The fluid is cooled at constant pressure until the piston comes back.What is the workdone in each process?	CO 1	T2:2.22
4	A reversible heat engine is supplied with heat from two constant temperature sources at 900K and 600K 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
5	Three Carnot engine are arranged in series.The first engine takes 4000kJ of heat from a source at 2000K and delivers 1800kJ of work. These cond and third engines deliver 1200kJ and 500kJ of work respectively. Compare the exhaust temperature of second and third Carnot engines?	CO 2	T2:3.22
6	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 or k which can be obtained from the system.	CO 2	T2:3.14 R1:4.33
7	Saturated steam has entropy of 6.76kJ/kgK. Interpret the pressure, temperature,specific volume,enthalpy from Mollier chart.	CO 3	T1:5.8 R1:5.73
8	At a temperature of 423K, 1kg of nitrogen occupies volume of 200liters. 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 3	T1:5.14 R1:6.78
9	Solve that for an ideal gas thes lope 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
10	Find the relative humidity and specific humidity for air at30°C and having dew point temperature of 15° C. Show the process.	CO 5	T1:10.4 R2:11.68
11	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 1 bar and 25°C, respectively. Find the mass of oxygen required and volume of the container.	CO 5	T1:7.12 R2:8.75

S.No	Topics to be covered	CO's	Reference
12	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
13	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.
14	Calculate an expression for air standard efficiency of diesel cycle	CO 6	T1:11.12 R2:12.75
15	Calculate an expression for air standard efficiency of dual cycle.	CO 6	T1:11.12 R2:12.75
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	System, surroundings, boundary, thermodynamic equilibrium, process, PMM1, state extensive property, Zeroth law of thermodynamics	CO 1,	T2:2.1
2	Reversible and Irreversible Processes, Second law of thermodynamics, enthalpy, entropy, Availability, Carnot Cycle,Carnot Heat Engine, PMM2, Entropy, Refrigerator,Heat pump	CO2	T2:3.1
3	Ideal gas,pure substance,p-V-T surface,dryness fraction,steam tables vanderwall's equation	CO 3,4	T1:5.1
4	psychrometric chart, WBT and DBT,humidity ratio, relative humidity, absolute humidity,degree of saturation,adiabatic saturation	CO 5	T1:7.1
5	Otto,Diesel,Dual combustion cycles,Brayton cycle, air standard efficiency	CO 6	T1: 11.12
DISCUSSION OF TUTORIAL QUESTION BANK			
1	Basic Concepts and First Law of Thermodynamics	CO 1	T2:2.1
2	Second Law of Thermodynamics	C02	T2:3.1
3	Pure Substances and Gas Laws	CO 3,4	T1:5.1
4	Mixtures of Perfect Gases	CO 5	T1:7.1
5	Power Cycles	CO 6	T1: 11.12

24. PROGRAM OUTCOMES & PROGRAM SPECIFIC 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
Program Specific Outcomes	
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.

25. 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.	2.6	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

26. 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 InterDisciplinary Engineering Applications.	2.8	AAT

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOME	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	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	✓	-

28. 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
	PS02	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
CO 2	PO 1	Recall the various statements of secondlaw of thermodynamics and the properties applied to various thermodynamic systems using (engineering fundamentals and science) and derive the relation ship between them using basic(mathematical equations).	3
	PO 2	Identify and formulate the statements of secondlaw of thermodynamics using first principles of mathematics,natural sciences,and engineering sciences.	6
	PSO 2	Formulate and Evaluate the equivalence of two statements of secondlaw of thermodynamics and the entropy principle using the concepts of Thermo-Fluid Systems to provide solutions for InterDisciplinary Engineering Applications.	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
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 puresubstances and steam to emit relevant inlet and exit conditions of thermodynamic systems used for the publichealth, 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 properties of airconditioning 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..	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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 4	Explain 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	Formulate and Evaluate the properties of pure substancesandsteamusingtheconceptsof Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications..	2

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

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

30. 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	-

31. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

2 - 40 % $<C<$ 60% –Moderate

1-5 $<C \leq 40\%$ – Low/ Slight

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

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

32. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓	Quiz	✓		

33. ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback
✓	Early Semester Feedback	✓	Assessment of activities/ Modeling & Experimental Tools in Engineering by Experts

34. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1		
2		

3	GOOD HEALTH AND WELL-BEING	
4	QUALITY EDUCATION	**Quality Education:** This subject will improve the quality education in engineers and gives the awareness in electrical usage in day-to-day life.
5	GENDER EQUALITY	
6	CLEAN WATER AND SANITATION	
7	AFFORDABLE AND CLEAN ENERGY	**Affordable and Clean Energy:** Understanding electrical circuits is crucial for developing sustainable energy solutions. Students who learn to design and optimize circuits can contribute to the development of efficient and clean energy systems, such as renewable energy sources and smart grids.
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Industry, Innovation, and Infrastructure: :** Engineering drawing principles is crucial for developing and maintaining sustainable infrastructure and technological innovations. It contribute to designing safer, more durable, and environmentally friendly infrastructure projects.Electrical circuits are the foundation of modern technology and infrastructure. The skills gained in this course are essential for creating and maintaining advanced infrastructure, including telecommunications, transportation, and manufacturing systems.
10	REDUCED INEQUALITIES	

11	SUSTAINABLE CITIES AND COMMUNITIES	
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	**Responsible Consumption and Production** This subject impacts the demand of electricity and need for saving energy
13	CLIMATE ACTION	
14	LIFE BELOW WATER	
15	LIFE ON LAND	
16	PEACE, JUSTICE AND STRONG INSTITUTIONS	
17	PARTNERSHIPS FOR THE GOALS	

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD,ME**
Dr. G Hima Bindu, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**MECHANICAL ENGINEERING**				
2	Course Title	**MANUFACTURING PROCESSES**				
3	Course Code	AMED08				
4	Program	B.Tech				
5	Semester	III Semester				
6	Regulation	BT-23				
7	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	0	3	2	1
8	Type of course (**Tick type of course**)	Core	Professional Elective	Open Elective	VAC	MOOCs
		✓	-	-	-	-
9	Course Offered	Odd Semester ✓		Even Semester ×		
10	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: .... hours		Tutorials: .... hours		Practical: .... hours	
11	Course Coordinator	Dr. Ch Sandeep				
12	Date Approved by BOS	12/08/2024				
13	Course Webpage	www.iare.ac.in/—-/—-				
14	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**	
		B.Tech	AMED02	II	Manufacturing Practice	

15. 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.

16. 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
IV	The environmental impact of different manufacturing processes and the importance of sustainable manufacturing practices

17. 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

18. Topic Learning Outcome (TLOs):

S.No	**Topic(s)**	**TLO No**	**Topic Learning Outcome's**	**Course Out-come**	Blooms Level
1	Introduction to Casting	1	**Explain** the fundamental steps involved in the casting process through a procedural approach	CO 1	Remember
		2	**Outline** the advantages and limitations of various casting methods for producing complex shapes	CO 1	Remember
		3	**Interpret** the role of mold materials for designing in the casting process.	CO 1	Remember

S.No	Topic(s)	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
		4	**Summarize** the impact of casting parameter on the quality of the final product	CO 1	Remember
2	Pattern Allowances	5	**Examine** the significance of each type of pattern allowance for creating patterns that lead to accurate and high-quality cast products	CO 1	Remember
		6	**Demonstrate** machining allowances to a pattern design for ensuring the final casting which can be machined to precise dimensions	CO 1	Remember
3	Welding	7	**Explain** the principles and mechanics behind different welding techniques for proficient welding and critical thinking abilities.	CO 1	Remember
		8	**Demonstrate** proper setup and use of welding equipment for different welding processes	CO 1	Remember
4	Soldering and Brazing	9	**Explain** the principles and mechanisms behind soldering and brazing processes for effective joint quality	CO 1	Remember
		10	**Understand** the role of fluxes in soldering and brazing to create proper techniques for strong and reliable joints	CO 2	Understand
5	Hot and Cold Working	11	**Understand** Kirchoff;s lawswithin the classroom and outside world.	CO 2	Understand
		12	**Understand** Source traansformation techniques within the classroom and outside world	CO 2	Understand
		13	**Understand** Passive elements likeRLC within the classroom and outside world	CO 2	Understand
6	Recrystallization and Grain Growth	14	**Understand** importance of star delta transfformation solving complex problems within the classroom and outside world	CO 2	Understand
7	Classify the types of Rolling	15	**Understand** importance of Mesh and Nodal Analysis solving problems within the classroom and outside world	CO 2	Understand
8	Stamping and forming operations	16	**Solve** problems with Super Mesh and Super Node	CO 2	Understand

S.No	Topic(s)	TLO No	Topic Learning Outcome's	Course Out-come	Blooms Level
9	Blanking and Piercing Operations	17	**Understand** DC Network Theorems to solve different types of Networks	CO 3	Understand
10	Wire and Tube Drawing Techniques	17	**Understand** AC Network Theorems to solve different types of Networks	CO 3	Understand
11	Hot and cold spinning	19	**Understand** Fundamental Principle of Electrical circuits	CO 4	Apply
12	Hydrostatic extrusion	20	**Understand** Self inductance of Inductive coils	CO 4	Apply
13	Additive manufacturing	21	**Able** to Find pplications of Series magnetic circuit	CO 5	Apply
14	Smith forging and drop forging	22	**Understand** Applications of Parallel magnetic circuits	CO 5	Apply
15	Rotary forging and defects	23	**Understand** Applications of Transmission lines	CO 5	Apply
16	Cold Forging	24	**Understnd** Importance of graph theory in electrical circuits	CO 6	Understand
17	Process of Swagging	25	**Understaand** the Applications of duality in electrical circuits	CO 6	Understand
18	Drop Forging	26	**Understaand** the Applications of duality in electrical circuits	CO 6	Understand

19. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
From maintaining power infrastructure to developing navigation and communications systems, electrical engineers play crucial roles across nearly every industry. With advanced electrical engineering skills, experts can lead the design, testing and manufacturing of the equipment that keep the world running.

20. Content Delivery / Instructional Methologies:

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

21. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Table 4: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	CIA - I	CIA - II	SEE	Total Marks
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

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 12 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

22. Course content - Number of modules: Five:

MODULE I	CASTING | Number of Lectures: 09
	Casting: Steps involved in making a casting, its applications, patterns and types of patterns, pattern allowances, types of casting processes, solidification of casting, casting defects.
MODULE II	WELDING | Number of Lectures: 09
	Welding: Welding types, Oxy-fuel gas welding, Arc welding Process, Resistance welding, Inert gas welding, TIG welding, MIG welding, Friction welding, Induction pressure welding, Electron beam welding, Laser welding, Soldering and Brazing. Heat affected zone in welding, welding defects, causes and remedies.

MODULE III	**METAL FORMING**	**| Number of Lectures: 10**
	Forming: Hot working, cold working, 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, stamping, forming. Blanking and piercing, bending and forming, drawing and its types, wire drawing and tube drawing; coining; hot and cold spinning.	
MODULE IV	**EXTRUSION AND RAPID PROTOTYPING**	**| Number of Lectures: 09**
	Extrusion of Metals: Basic extrusion process and its characteristics, hot extrusion and cold extrusion, forward extrusion and backward extrusion, impact extrusion, tube extrusion and Pipe making, hydrostatic extrusion; Additive manufacturing: Rapid prototyping and rapid tooling.	
MODULE V	**FORGING**	**| Number of Lectures: 08**
	Forging operations and principles, tools, smith forging, drop forging, roll forging, rotary forging, forging defects, cold forging, swaging.	

TEXTBOOKS

1. Kalpakjian and Schmid, "*Manufacturing processes for engineering materials*", Pearson India, 10th Edition, 2019.

2. R K Jain, "*Production Technology*", Pearson India, 11th Edition, 2019.

REFERENCE BOOKS:

1. Mikell P. Groover, "*undamentals of Modern Manufacturing: Materials, Processes and Systems*", John Wiley and Sons Inc, 5th Edition, 2014.

2. Degarmo, Black and Kohser, "*Materials and Processes in Manufacturing*", John Wiley and Sons Inc, 9th Edition, 2013.

MATERIALS ONLINE:

1. https://www.nptel.ac.in/courses/112106286

2. https://www.akanksha.iare.ac.in

3. https://www.bernierinc.com

4. https://www.twi-global.com

23. COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping		
CONTENT DELIVERY (THEORY)			
1	Introduction to manufacturing processes	CO 1	T1: 2.1
2	Review on casting and pattern	CO 1	T1:2.4
3	Discuss the casting processes and their types	CO 1	T1:2.4
4	Describe the solidification of casting	CO 1	T1:2.5
5	Types of patterns	CO 1	T1: 2.1
6	Patterns Allowances and thier construction	CO 1	T1:2.4
7	Casting defects	CO 1	T1:2.4
8	Types of welding techniques	CO 2	T1:1.5- 1.6
9	Oxy-Fuel gas welding	CO 2	T1:1.8- 1.12
10	Arc Welding	CO 1	T1: 2.1
11	Resistance welding	CO 2	T1:1.13- 1.18
12	Inert gas welding	CO 2	T1:1.1- 1.18
13	TIG and MIG welding	CO 2	T1:5.1- 5.2
14	Friction welding	CO 2	T1:5.3
15	Discuss the effect of Heat affected zone in welding	CO 2	T1:5.7
16	Discuss the welding defects	CO 2	T1:5.4- 5.6
17	Discuss the causes and remedies	CO 2	T1:6.5- 6.11
18	Laser Welding	CO 3	T1:7.1-7.4
19	Soldering and Brazing	CO 3	T1:5.3
20	Discuss the hot and cold working	CO 3	T1:5.7
21	Discuss about recrystallization and grain growth	CO 3	T1:5.1- 5.2
22	Introduction to rolling	CO 3	T1:5.3
23	Demonstration of working of rolling operations	CO 3	T1:5.7
24	Classify the types of rolling	CO 3	T1:5.4- 5.6
25	Introduction to mills and products and stamping	CO 3	T1:6.5- 6.11
26	Demonstration of forces in rolling and their calculations	CO 3	T1:7.1-7.4
27	Discuss stamping forming and other cold operations	CO 3	T1:8.4- 8.6
28	Demonstarte of blanking and piercing operations	CO 3	T1: 8.12-8.15
29	Introduction to drawing and its types	CO 3	T1:8.4- 8.6
30	Discuss the wire and tube drawing techniques	CO 4	T1: 8.12-8.15
31	Coining, Hot and cold spinning	CO 4	T1:8.4- 8.6

S.No	Topics to be covered	CO's	Reference
32	Describe the importance of impact and extruding equipment	CO 3	T1: 8.12-8.15
33	Describe hydrostatic extrusion, forces in extrusion	CO 4	T1:8.4- 8.6
34	Introduction to Additive manufacturing	CO 5	T1: 8.12-8.15
35	Describe the Smith forging, drop forging	CO 5	T1:8.4- 8.6
36	Discuss the rotary forging and forging defects	CO 5	T1: 8.12-8.15
37	Describe the cold forging	CO 5	T1:8.4- 8.6
38	Describe the process of Swaging	CO 6	T1: 8.12-8.15
39	Drop forging	CO 6	T1:8.4- 8.6
40	Advanced manufacturing techniques	CO 6	T1:8.12-8.15
PROBLEM SOLVING/ CASE STUDIES			
1	Case study on casting defects	CO 2	T1:10.8
2	Case study on pattern and core	CO 2	T1:10.9- 10
3	Case Study on Aluminum Die Casting	CO 2	T4:10.10
4	Welding temperature at heat effected zone	CO 2	T1:8.2
5	Calculation of gas required for oxy-Fuel gas welding	CO 3	T1:1.1
6	Composition in thermit welding	CO 3	T1:1.5- 1.6
7	Identification of electrodes in resistance welding	CO 3	T1:1.8- 1.12
8	Types of flames in oxy-Acetlyene welding	CO 3	T1:1.13- 1.18
9	Residual stress in hot and cold workin g process	CO 3	T1:1.19.1- 1.19.2
10	Discuss the types of rolling in metal forming process	CO 3	T1:1.19.1- 1.19.2
11	Identification of defects in extrusion process	CO 4	T1:1.193
12	Selection of different materials in Additive manufacturing process	CO 4	T1:1.19.6
13	Explain the different types of extrusion process	CO 5	T1:1.19.
14	Identification of failures in dies metal working process	CO 5	T1:2.11.1
15	Identify the defects in extrusion	CO 5	T1:2.11.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Introduction to Casting	CO 1, CO2	R4:2.1
2	Welding, Soldering and Braxzing	CO3	T4:7.3
3	Metal Forming	CO 4	R4:5.1
4	Extrusion and Rapid Prototyping	CO 5	T1:7.5
5	Forging	CO 6	T1: 4.1
DISCUSSION OF TUTORIAL QUESTION BANK			
1	Introduction to Casting	CO 1, CO2	R4:2.1
2	Welding, Soldering and Brazing	CO3	T4:7.3
3	Metal Forming	CO 4	R4:5.1

S.No	Topics to be covered	CO's	Reference
4	Extrusion and Rapid Prototyping	CO 5	T1:7.5
5	Forging	CO 6	T1: 4.1

24. PROGRAM OUTCOMES & PROGRAM SPECIFIC 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

Program Outcomes	
Program Specific Outcomes	
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 creating innovative career paths, to be an entrepreneur and desire for higher studiesr.

25. 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	Assignments

26. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies	2	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

27. 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	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-

28. 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
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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
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
CO 6	PO 1	Explain (understand) the process parameter using (complex) the functions of engineering problems by applying the principles of mathematics and engineering fundamentalsy.	2
	PO 2	Categorise the concept of Forging Techniques based upon the information and data collection in engineering problems.	2

29. 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	-	-	-	-	-	-	-	-	-	-	-	-	-

30. 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	-	-	-	-	-	-	-	-	-	-	-	-	-

31. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

2 - 40 % $<C < 60\%$ –Moderate

1-5 $<C\leq 40\%$ – Low/ Slight

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

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

32. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓	Quiz	✓		

33. ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback
✓	Early Semester Feedback	✓	Assessment of activities/ Modeling & Experimental Tools in Engineering by Experts

34. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1		
2		
3		
4		**Quality Education:** This subject will improve the quality education in engineers and gives the awareness in manufacturing process usage in day-to-day life.
5		
6		

7	AFFORDABLE AND CLEAN ENERGY	**Affordable and Clean Energy:** Achieving affordable and clean energy in manufacturing involves using energy-efficient equipment, integrating renewable energy sources like solar and wind, optimizing processes through smart technologies, and adopting sustainable practices such as waste heat recovery and circular economy models. Collaboration with industry partners and leveraging government incentives can further support these initiatives.
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Industry, Innovation, and Infrastructure: :** Industry innovation and infrastructure in manufacturing focus on integrating advanced technologies like IoT, AI, and robotics to enhance efficiency and productivity. Upgrading infrastructure to support smart manufacturing and adopting sustainable practices ensure resilience and environmental sustainability. Collaboration with research institutions and investment in cutting-edge technology drive continuous improvement and competitiveness.
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	**Responsible Consumption and Production** Responsible consumption and production in manufacturing involve minimizing waste through efficient resource use and recycling, adopting sustainable materials, and reducing environmental impact. Implementing circular economy practices ensures products are designed for longevity and recyclability. Monitoring and optimizing supply chains enhance sustainability, while transparent reporting promotes accountability
13	CLIMATE ACTION	

14		
15		
16		
17		

Approved by: Board of Studies in the meeting conducted on ——————————.

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

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

<table>
<tr><td>1</td><td>Department</td><td colspan="5">MECHANICAL ENGINEERING</td></tr>
<tr><td>2</td><td>Course Title</td><td colspan="5">DATA STRUCTURES</td></tr>
<tr><td>3</td><td>Course Code</td><td colspan="5">ACSD08</td></tr>
<tr><td>4</td><td>Class / Semester</td><td colspan="5">B.Tech III Semester</td></tr>
<tr><td>5</td><td>Regulation</td><td colspan="5">BT-23</td></tr>
<tr><td rowspan="3">6</td><td rowspan="3">Structure of the course</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Lab</td><td>Credits</td></tr>
<tr><td>3</td><td>0</td><td>3</td><td>-</td><td>-</td></tr>
<tr><td rowspan="2">7</td><td rowspan="2">Type of course
(Tick type of course)</td><td>Core</td><td>Professional Elective</td><td>Open Elective</td><td>VAC</td><td>MOOCs</td></tr>
<tr><td>✓</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>8</td><td>Course Offered</td><td colspan="2">Odd Semester ✓</td><td colspan="3">Even Semester ×</td></tr>
<tr><td rowspan="2">9</td><td colspan="6">Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)</td></tr>
<tr><td colspan="2">Lectures: 48 hours</td><td colspan="2">Tutorials: 0 hours</td><td colspan="2">Practical: – hours</td></tr>
<tr><td>10</td><td>Course Coordinator</td><td colspan="5">Mr. D. Atchuta Ramacharyulu</td></tr>
<tr><td>11</td><td>Date Approved by BOS</td><td colspan="5">22/08/2023</td></tr>
<tr><td>12</td><td>Course Webpage</td><td colspan="5">https://www.iare.ac.in/?q=pages/btech-course-syllabi-bt23-cse</td></tr>
<tr><td rowspan="2">13</td><td rowspan="2">Course Prerequistes</td><td>Level</td><td>Course Code</td><td>Semester</td><td colspan="2">Prerequisites</td></tr>
<tr><td>B.Tech</td><td>ACSD01</td><td>I</td><td colspan="2">OOPs with JAVA</td></tr>
</table>

14. 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.

15. Course Objectives:

The students will try to learn:

I	The skills needed to understand and analyze performance trade-offs of different algorithms / implementations and asymptotic analysis of their running time and memory usage.
II	The 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	The implementing these data structures and algorithms in Python.
V	The essential for future programming and software engineering courses.

16. 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

17. Mapping of topic learning outcomes (TLO) to course outcomes

S. No	Topic(s)	TLO No	Topic Learning Outcome's	Course Outcome	Blooms Level
1	Introduction to data structures	1	Understand various data structures to solve real-time problems.	CO 1	Understand
2	Classification of data structures, Operations on data structures	2	Understand the classification and operations of various data structures.	CO 1	Understand
3	Recursive algorithms and performance analysis	3	Understand the specifications of writing algorithms, developing recursive procedures.	CO 1	Understand
4	Searching Techniques: Linear Search, Binary Search	4	Apply knowledge of searching techniques to solve real word applications.	CO 2	Apply
5	Uniform Binary Search, Interpolation Search				
6	Fibonacci Search and comparison				

S. No	Topic(s)	TLO No	Topic Learning Outcome's	Course Outcome	Blooms Level
7	Sorting techniques: Bubble, Selection sort	5	Apply knowledge of sorting techniques to solve real word applications.	CO 2	Apply
8	Insertion, Quick sort				
9	Merge, Radix sort, Shell sort and comparison				
10	Stack ADT, definition and operations, Implementations of stacks using array	6	Understand stack data structure and apply the knowledge to perform infix to postfix conversion and postfix evaluation.	CO 3,CO 4, CO 6	Apply
11	Applications of stacks, Arithmetic expression conversion and evaluation				
12	Queues: Primitive operations; Implementation of queues using Arrays	7	Understand stack data structure and apply the knowledge to solve real world applications.	CO 3,CO 4, CO 6	Apply
13	Applications of linear queue, circular queue				
14	double ended queue (deque)				
15	Linked lists: Introduction, singly linked list, representation of a linked list in memory	8	Apply linked list data structure to perform polynomial representation and sparse matrix manipulation	CO 3,CO 4, CO 6	Apply
16	operations on a single linked list, Applications of linked lists Polynomial representation				
17	Sparse matrix manipulation				
18	Types of linked lists: Circular linked lists	9	Understand types of linked lists and implement stack and queue mechanisms using linked list.	CO 3,CO 4, CO 6	Apply
19	doubly linked lists				
20	Linked list representation and operations of Stack				
21	Linked list representation and operations of queue				

S. No	Topic(s)	TLO No	Topic Learning Outcome's	Course Outcome	Blooms Level
22	Trees: Basic concept, binary tree	10	Understand the concept of trees and various methods of its representation.	CO 3	Apply
23	binary tree array representation				
24	binary tree linked list representation				
25	binary tree traversal	11	Understand inorder, preorder and post order traversals of trees.	CO 3	Apply
26	Binary tree variants	12	Understand various variants of binary trees in real world applications.	CO 3	Apply
27	Threaded binary tree				
28	Application of trees	13	Apply the knowledge of variants of binary trees and its operations to solve real world problems.	CO 4	Apply
29	Graphs: Basic concept, graph terminology	14	Understand the basics of graphs, its representation and implementation.	CO 3	Apply
30	Graph Representations-Adjacency matrix, Adjacency lists				
31	Graph implementation				
32	Graph traversals – BFS	15	Apply the basics of graphs, its representation to implement graph traversals.	CO 3,CO 4, CO 6	Apply
33	Graph traversals – DFS				
34	Application of graphs				
35	Minimum spanning trees – Prims and Kruskal algorithms	16	Understand the concept of spanning tress and two algorithms for finding minimum spanning trees	CO 3,CO 4, CO 6	Apply
36	Binary search trees: Binary search trees, properties and operations	17	Understand the concept of binary search tree with its variants.	CO 3	Understand
37	Balanced search trees: AVL trees				
38	Introduction to M-Way search trees	18	Understand various generalized versions of binary tress.	CO 3,CO 4, CO 6	Understand
39	B trees				
40	Hashing and collision	19	Apply the concept of hashing in real world applications for data fast retreival.	CO 5	Apply

18. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
1. Programming skills - The tech industry evolves rapidly, and staying up-to-date with the latest programming languages, frameworks, and development practices is crucial. Combining essentials of problem solving skills with a commitment to continuous learning demonstrates a student's dedication to staying relevant in a dynamic field.
2. Project-based skills - Creating projects that utilize graph theory principles to allow a student to apply theoretical knowledge to real-world scenarios. This hands-on experience helps solidify their understanding of how problem solving concepts work in practice.

19. Content Delivery / Instructional Methologies:

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

20. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for each Definition and Terminology / Quiz, and the remaining 10 marks for Tech Talk / Assignments.

Table 4: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	40 Marks
Total	-	-	**100 Marks**	

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 12 marks. There could be a maximum of two sub divisions in a question.

21. Course content - Number of modules: Five

MODULE I	**INTRODUCTION TO DATA STRUCTURES, SEARCHING AND SORTING | Number of Lectures: 9**
	Basic concepts: Introduction to data structures, classification of data structures, operations on data structures, Algorithm Specification, Recursive algorithms, Data Abstraction, Performance analysis- time complexity and space complexity, Introduction to Linear and Non Linear data structures **Searching techniques:** Linear and Binary search, Uniform Binary Search, Interpolation Search, Fibonacci Search; **Sorting techniques:** Bubble, Selection, Insertion, and Quick, Merge, Radix and Shell Sort and comparison of sorting algorithms.
MODULE II	**LINEAR DATA STRUCTURES | Number of Lectures: 9**
	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 |Number of Lectures: 9**
	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 | Number of Lectures: 9**
	Trees: Basic concept, binary tree, binary tree representation, array and linked representations, binary tree traversal, binary tree variants, threaded binary trees, 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 | Number of Lectures: 9**
	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:** ntroduction, 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.

Electronic Resources:

1. https://www.tutorialspoint.com/data_structures_algorithms/algorithms_basics.htm
2. https://www.codechef.com/certification/data-structures-and-algorithms/prepare
3. https://www.cs.auckland.ac.nz/software/AlgAnim/dsToC.html
4. https://online-learning.harvard.edu/course/data-structures-and-algorithms

22. COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
	Discussion on OBE		
1	Discussion on Outcome Based Education, CO, POs and PSOs		
	Content Delivery (Theory)		
1	Introduction to data structures	CO 1	T1:1.1.3 R2 : 1.4
2	Classification of data structures, Operations on data Structures	CO 1	T1:1.1.3 R2 : 1.4
3	Recursive algorithm, Performance Analysis	CO 1	T1:1.2 T1:5.1
4	Searching techniques: Linear search, binary search	CO 2	T1:5.1
5	Searching techniques: Uniform binary search and interpolation search	CO 2	T1:5.1
6	Searching techniques: Fibonacci search and comparison	CO 2	T1:5.1
7	Sorting techniques: Bubble sort, selection sort	CO 2	R1:14.5
8	Sorting techniques: Insertion sort, Quick sort	CO 2	T1:5.2 R2: 10.2
9	Sorting techniques: Merge sort and Radix sort, Shell sort and comparison of sorting algorithms	CO 2	T1:5.2 R2 : 10.2
10	Stacks ADT, definition and operations, implementation of stacks using Arrays	CO 3, CO 6	T1:7.1
11	Applications of stacks, arithmetic expression conversion and evaluation	CO 4, CO 6	T1:7.2
12	Queues: Primitive operations; Implementation of queues using Array	CO 3	T1:8.1
13	Applications of linear queue, circular queue	CO 4	T1:8.4
14	Double ended queue (deque)l	CO 3	R2 : 5.4
15	Linked lists: Introduction, singly linked list, representation of a linked list in memory	CO 3	T1:9.1
16	Operations on a single linked list, Applications of linked lists - Polyomial representation	CO 3	T1:9.2
17	Sparse matrix manipulation	CO 4, CO 6	T1:9.3

S.No	Topics to be covered	CO's	Reference
18	Types of linked lists:Circular linked lists	CO 3	T1:9.3
19	double linked lists	CO 3	T1:9.4
20	Linked list representation and operations of Stack	CO 3	T1:9.4
21	Linked list representation and operations of queue	CO 3	T1:9.4
22	Trees: Basic concept, Binary Tree	CO 3	T1:13.1
23	Binary tree representation using array	CO 3	T1:13.2
24	Binary tree representation using linked list	CO 3	T1:13.2
25	Binary tree traversal	CO 3	T1:13.2
26	Binary tree variants	CO 3	T1:13.2
27	Threaded binary tree	CO 3	T1:13.2
28	Application of trees	CO 4	T1:13.2.3
29	Graphs: Basic concept, graph terminology	CO 3	R2 : 8.2
30	Graph representation- Adjacency matrix, adjacency list	CO 3	R2 : 8.2
31	Graph implementation	CO 3	R2 : 8.2
32	Graph traversals BFS	CO 3, CO 4, CO 6	T2:6.2
33	Graph traversals :DFS	CO 3, CO 4, CO 6	T2:6.2
34	Application of graphs	CO 3, CO 4, CO 6	T2:6.2
35	Minimum Spanning Trees-Prims and Kruskal algorithms	CO 3, CO 4, CO 6	T1:6.1 T2:5.6
36	Binary search trees, properties and operations	CO 3	T1:13.2.3
37	AVL trees	CO 3	T1:13.2.3
38	M- Way search trees, B trees	CO 3, CO 4, CO 6	T1:14.3
39	B trees	CO 3	T1:14.3
40	Hashing, Collision	CO 5	R2 : 6.4
Problem Solving/Case Studies			
1	Problems on linear search, binary search and Fibonacci search.	CO 2	T1:5.1
2	Problems on bubble sort, selection and insertion sort	CO 2	T1:5.2 R2 : 10.2
3	Problems on quick and merge sort	CO 2	T1:5.2 R2 : 10.2
4	Problems on Arithmetic expression conversion and evaluation	CO 4 CO 4	T1:7.2
5	Problems on single linked list to add, delete element	CO 3, CO 4	T1:9.8
6	Problems on double linked list to add, delete element	CO 3, CO 4	T1:9.8
7	Problems on circular linked list to add, delete element	CO 3, CO 4	T1:9.4
8	Problems on double linked list to add, delete element	CO 3, CO 4	T1:9.3
9	Problems on stack using linked list	CO 3, CO 4	T1:9.7

S.No	Topics to be covered	CO's	Reference
10	Problems on queue using linked list	CO 3, CO 4	T1:9.8
11	Problems on Binary tree :creation ,insertion and deletion of a node	CO 3	T1:13.2
12	Problems on Graph Traversal: DFS and BFS	CO 3, CO 4	T2:6.2
13	Problems on MST: Prim's and Kruskal's	CO 3, CO 4	T1:6.1 14:5.6
14	Problems on Binary search tree	CO 4	T1:14.3
15	Problems oh hashing	CO 5	R2 : 6.4
Definition and Terminology			
1	Data Structures, Searching and Sorting	CO 1,CO2,CO 3	T1:1 R1:14
2	Linear Data Structures - Stack, Queue	CO 3	T1:7,.T1:8
3	Linked Lists - Single Linked List, Double Linked List, Circular Linked Lists	CO 3	T1:9
4	Non Linear data Structures - Trees, Graphs	CO 3	T1:7.5
5	Binary Trees, Binary Search Tree, Hashing and Collision	CO 3 CO 5	T1:14
Tutorial Question Bank			
1	Introduction to Data Structures, Searching and Sorting	CO 1, CO2,CO6	T1:1 R1:14
2	Linear Data Structures	CO 3,CO 4,CO 6	T1:9
3	Linked Lists	CO 3,CO 4,CO 6	T1:2.5
4	Non Linear Data Structures	CO 3,CO 4,CO 6	T1: 4.1
5	Binary Trees and Hashing	CO 3,CO 5,CO 6	T1: 5.1

23. PROGRAM OUTCOMES & PROGRAM SPECIFIC 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
Program Specific Outcomes	
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.

24. 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/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	1	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.	1	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/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/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/Open ended Experiments

25. 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	CIE/ SEE/ Tech Talk/ Open ended experiments

3 = High; 2 = Medium; 1 = Low

26. 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	✓	✓	✓	✓	✓	-	-	-	-	✓	-	✓	-	-	✓

27. 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
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
	PSO3	**Make use of modern** computer tools for finding space and time complexities of a complex algorithm	1

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
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
	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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	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
	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
	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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	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
	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 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

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

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

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

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

30. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

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

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
AVERAGE	2.0	2.4	1.3	1.0	3.0	-	-	-	-	1	-	1	-	-	1.0

31. ASSESSMENT METHODOLOGY DIRECT:

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

32. ASSESSMENT METHODOLOGY INDIRECT:

-	Assessment of mini Projects by Experts	✓	End Semester OBE Feedback

33. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1		
2		
3		

4		Quality education: Guarantee an education system that is both inclusive and fair, offering high-quality learning experiences and lifelong opportunities accessible to all.
5		
6		
7		
8		
9		Industry, innovation, and infrastructure: Strong problem solving skills with appropriate data structures enable to design and development of services like microservice architecture, cloud computing, machine learning, and AI integration in a modular and maintainable way, contributing to a more flexible and scalable infrastructure.

10		
11		Sustainable cities and communities: Programming skills with appropriate use of data structures can develop software solutions that contribute to urban sustainability, improve quality of life, and address challenges like smart city solutions, energy efficiency and monitoring, waste management systems, public transportation optimization, environmental sensor networks, education, and awareness faced by modern cities.
12		
13		
14		
15		

16		
17		

Approved by: Board of Studies in the meeting conducted on 13-08-2024.

Signature of Course Coordinator **HOD, ME**

Mr. D. Atchuta Ramacharyulu, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

<table>
<tr><td>1</td><td>Department</td><td colspan="4">MECHANICAL ENGINEERING</td></tr>
<tr><td>2</td><td>Course Code</td><td colspan="4">AMED09</td></tr>
<tr><td>3</td><td>Course Title</td><td colspan="4">Solid Mechanics and Materials Laboratory</td></tr>
<tr><td>4</td><td>Semester</td><td colspan="4">III Semester</td></tr>
<tr><td>5</td><td>Regulation</td><td colspan="4">BT-23</td></tr>
<tr><td rowspan="3">6</td><td rowspan="3">Structure of the course</td><td colspan="4">Practical</td></tr>
<tr><td colspan="3">Lecture Hours</td><td>Practical Hours</td></tr>
<tr><td colspan="3">–</td><td>2</td></tr>
<tr><td>7</td><td>Course Offered</td><td colspan="2">Odd Semester ✓</td><td colspan="2">Even Semester ×</td></tr>
<tr><td>8</td><td>Course Coordinator</td><td colspan="4">Dr. k. Ch Apparao</td></tr>
<tr><td>9</td><td>Date Approved by BOS</td><td colspan="4">12/08/2024</td></tr>
<tr><td>10</td><td>Course Webpage</td><td colspan="4">https://www.iare.ac.in/?q=pages/btech-course-syllabi-bt23-me</td></tr>
<tr><td rowspan="2">11</td><td rowspan="2">Course Prerequistes</td><td>Level</td><td>Course Code</td><td>Semester</td><td>Prerequisites</td></tr>
<tr><td>–</td><td>–</td><td>–</td><td>-</td></tr>
</table>

12. 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.

16. 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.

14. 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

15. Employability Skills:

1. **Employment advantage:** This can give competitive advantage when seeking employment to apply knowledge about engineering tools used in manufacturing of products.
2. **Programming skills:** Understanding basics of CNC programming for application in laying, shaping and cutting process for product development.
3. **Project based skills:** This can give hands on experience for design, analysis and fabrication of prototype model for real time applications.
4. **Safety Awareness:** Understanding the different machines, instruments and tools to handle in real-time environment. Graduates can apply this awareness to workplaces where safety is a priority.

16. Content delivery / Instructional methologies:

✓	Day to Day lab evaluation	x	Demo Video	✓	Viva Voce questions	✓	Open Ended Experiments
x	Competitions	x	hackathons	x	Certifications	✓	Probing Further Questions

17. Evaluation methodology:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or)

Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

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.

Table 4: Experiment based

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

Table 5: Programming based

Objective	Analysis	Design	Conclusion	Viva voce	Total
–	–	–	–	–	20

Semester End Examination:

The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.

In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

18. Course content:

CO 1	**Utilize the concepts crystallography, crystal structures, crystallographic planes, and miller indices to analyse the microstructural properties of materials.**
	1. Preparation of the specimen for studying the microstructure of Aluminium. 2. Find the grain size of microstructure of Aluminium . Solutions Expected: a. Preparation of specimen b. Learn to operate microscope c. Studying the microstructure **Try** 1. Preparation of the specimen for studying the microstructure of Al-Si alloy 2. Preparation of the specimen for studying the microstructure of Al-Zn alloy
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.**
	1. Preparation of the specimen for studying the microstructure of copper. 2. Find the grain size of microstructure of copper . Solutions Expected: a. Preparation of specimen b. Learn to operate microscope c. Studying the microstructure **Try** 1. Preparation of the specimen for studying the microstructure of Cl-Si alloy 2. Preparation of the specimen for studying the microstructure of Cl-Zn alloy
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.**
	1. Preparation of LAP JOINT using Arc Welding Process . 2. Preparation of LAP JOINT using Arc Welding Process for different size. **Try** 1. Preparation of BUTT JOINT using Arc Welding Process. 2. To simulate and analyze the arc welding process using computer-aided engineering (CAE) software.
CO 4	**Analyze the mechanical properties of a material by conducting compression and torsion tests on different materials.**
	1. Making of flange mould using a given pattern. 2. Utilizing the provided pattern, create the bearing housing mould. **Try** 4.1 Making of dumble using a given pattern. 4.2 Using a single-piece pattern, create a one-stepped shaft .

CO 5	**Compare the hardeness values of ferrous and non ferrous materials by conducting experiments on Rockwell and Brinell's hardness testing machines..**
	1. To perform blanking and piercing operations and determine the punching force and blanking force theoretically. 2. To perform blanking and piercing operations and determine the punching force and blanking force theoretically . **Try** 1. Prepare blanking and piercing operations on different materials. 2. To design a progressive die using CAD software, focusing on creating a series of operations that transform a metal strip into a finished part, with multiple stages in a single die.
CO 6	**Determine the impact strength of a material by adopting Charpy and Izod test procedures.**
	1. Perform injection moulding operation for given plastic raw material 2. Perform injection moulding operation for given plastic raw material **Try** 1. Perform the Moulding for mixer grinder from a circuit board. 2. To design and simulate an injection mold using CAD software, ensuring that the mold will produce high-quality parts efficiently and reliably.

TEXTBOOKS

1. Rajput, "*Strength of Materials*", Rajsons, Publications, 21st Edition, 2017.
2. R K Bansal, "*Strength of Materials*", 2nd Edition, 2008.

REFERENCE BOOKS:

1. S S Rattan, "*A Text Book of strength of Materials*",Laxmi Publications, 9th Edition, 2015.
2. Popov, "*Mechanics of materials, Wiley*", 3rd Edition, 2008.

MATERIALS ONLINE:

1. Lab manual
2. Question bank

19. 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	R1:11.1-11.5
2	Preparation and study of the microstructure of mild steels, low carbon steels, high–C steels.	CO 1	R1:4.8,R1:7.2
3	Study of the micro structures of cast irons.	CO 1	R1:6.3-6.52
4	Study of the micro structures of copper.	CO 2	R1:10.1-10.2
5	Study of the micro structures of high carbon steel.	CO 2	R2:12.6, R1:5.2
6	To Find the percentage of elongation and youngs modulus of a material.	CO 3	R1:9.3-9.5
7	Find the torsional rigidity of a material	CO 4	R2:10.4-10.7
8	Find the torsional rigidity of a material	CO 4	R2:3.12
9	Find the Hardness number of given material.	CO 5	R1:2.18
10	Testing on compressive and elongation springs.	CO 6	R2:13.8 - 13-11
11	Compression test on concrete cube.	CO 6	R2:14.2-14-6
12	Find the Imapct strength of a given specimen	CO 6	R1:17.4-17-5
13	Find the Imapct strength of a given specimen.	CO 6	R1:15.3-15-5
14	Punch shear test on aluminium sheet.	CO 6	R2:9.5-9-7

20. Experiments for enhanced learning (EEL):

S.No	Product 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

21. Program Outcomes and Program Specific 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
Program Specific Outcomes	
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 start-ups, employability and higher studies.

22. 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
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	Lab Exercises
PO 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

23. 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	Lab Exercises / CIE / SEE

3 = High; 2 = Medium; 1 = Low

24. 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	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-

25. 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	Apply the science, mathematics and engineering knowledge to understand the concepts of digital manufacturing	3

26. 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	4	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	-	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 5	-	3	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 6	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-

27. Percentage of key competencies 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	80	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	100	70	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	50	-	-	40	-	-	-	-	-	-	-	-	-	-	-
CO 4	50	-	-	-	-	-	-	-	-	-	-	-	100	-	-
CO 5	-	70	-	50	-	-	-	-	-	-	-	-	-	-	-
CO 6	-	70	-	-	-	-	-	-	-	-	-	-	-	-	-

28. Course articulation matrix PO / PSO mapping:

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	-	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 5	-	3	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 6	-	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
Total	10	12	-	4	-	-	-	-	-	-	-	-	3	-	-
Average	2.5	3	-	2	-	-	-	-	-	-	-	-	3	-	-

29. Assessment methodology -Direct:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

30. Assessment methodology -Indirect:

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

31. Relevance to Sustainability goals (SDGs):

Write brief description about the course and how its relevance to SDGs.

1	NO POVERTY	
2	ZERO HUNGER	
3	GOOD HEALTH AND WELL-BEING	
4	QUALITY EDUCATION	**Quality Education:** The engineering workshop course provides students with a strong foundation and allows them to apply knowledge about engineering tools used in manufacturing of products.
5	GENDER EQUALITY	

6	CLEAN WATER AND SANITATION	
7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	**Responsible Consumption and Production:** Focusing on efficient material use and waste reduction in engineering workshops can aid in the developing of components/products.
13	CLIMATE ACTION	
14	LIFE BELOW WATER	

15	LIFE ON LAND	
16	PEACE, JUSTICE AND STRONG INSTITUTIONS	
17	PARTNERSHIPS FOR THE GOALS	

Approved by: Board of Studies in the meeting conducted on 24.08.2023.

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

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

<table>
<tr><td>1</td><td>Department</td><td colspan="4">MECHANICAL ENGINEERING</td></tr>
<tr><td>2</td><td>Course Code</td><td colspan="4">AMED10</td></tr>
<tr><td>3</td><td>Course Title</td><td colspan="4">MANUFACTURING PROCESSES LABORATORY</td></tr>
<tr><td>4</td><td>Semester</td><td colspan="4">III Semester</td></tr>
<tr><td>5</td><td>Regulation</td><td colspan="4">BT-23</td></tr>
<tr><td rowspan="2">6</td><td rowspan="2">Structure of the course</td><td colspan="4">Practical</td></tr>
<tr><td colspan="3">Lecture Hours
–</td><td>Practical Hours
2</td></tr>
<tr><td>7</td><td>Course Offered</td><td colspan="2">Odd Semester ✓</td><td colspan="2">Even Semester ×</td></tr>
<tr><td>8</td><td>Course Coordinator</td><td colspan="4">Dr. Ch Sandeep</td></tr>
<tr><td>9</td><td>Date Approved by BOS</td><td colspan="4">12/08/2024</td></tr>
<tr><td>10</td><td>Course Webpage</td><td colspan="4">https://www.iare.ac.in/?q=pages/btech-course-syllabi-bt23-me</td></tr>
<tr><td rowspan="2">11</td><td rowspan="2">Course Prerequistes</td><td>Level</td><td>Course Code</td><td>Semester</td><td>Prerequisites</td></tr>
<tr><td>–</td><td>–</td><td>–</td><td>No prerequisites</td></tr>
</table>

12. Course Overview:

Manufacturing Practice laboratory is intended to enhance the learning experience of the students with new tools, equipment, and techniques for creating physical objects and mechanisms with a variety of materials. Skills learned in the course enable analogous learning about the design process in digital manufacturing used in various industrial applications and empowers the students to understand modern concepts of manufacturing technologies.

13. 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	The design features that make each of this manufacturing process both harder, easier, assess design and manufacturing features on real products.

14. Course outcomes:

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

CO 1	**Identify** the design steps involved in making a casting for automotive components.	Apply
CO 2	**Demonstrate** practical usage of Gas welding and Arc welding techniques for making Lap and Butt joints.	Apply
CO 3	**Make use of** different types of welding techniques for Industrial Applications.	Apply
CO 4	**Analyze** various defects during gas welding, arc welding process and their causes and remedies.	Apply
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

15. Employability Skills:

1. **Employment advantage:** This can give competitive advantage when seeking employment to apply knowledge about engineering tools used in manufacturing of products.
2. **Programming skills:** Understanding basics of CNC programming for application in laying, shaping and cutting process for product development.
3. **Project based skills:** This can give hands on experience for design, analysis and fabrication of prototype model for real time applications.
4. **Safety Awareness:** Understanding the different machines, instruments and tools to handle in real-time environment. Graduates can apply this awareness to workplaces where safety is a priority.

16. Content delivery / Instructional methologies:

✓	Day to Day lab evaluation	x	Demo Video	✓	Viva Voce questions	✓	Open Ended Experiments
x	Competitions	x	hackathons	x	Certifications	✓	Probing Further Questions

17. Evaluation methodology:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

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.

Table 4: Experiment based

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

Table 5: Programming based

Objective	Analysis	Design	Conclusion	Viva voce	Total
–	–	–	–	–	20

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

18. Course content:

CO 1	**Identify the design steps involved in making a casting for automotive componentsg**
	1. Design and prepare a wooden pattern for the given casting with consideration of suitable allowances. 2. Prepare a wooden pattern for the given casting. **Try** 1. Design and analyze a wood pattern using computer-aided design (CAD) software and to simulate the casting process to ensure the pattern's accuracy and effectiveness. 2. Design a pattern for the casting which is to be made of steel by considering Shrinkage and Draft allowance.
CO 2	**Demonstrate practical usage of Gas welding and Arc welding techniques for making Lap and Butt joints.**
	1. Preparation of V – Butt Joint Using TIG Welding . 2. Preparation of Lap Joint on the given work pieces using spot welding equipment. **Try** 1. Preparation of Mild Steel (MS) T Joint using TIG welding. 2. To simulate and analyze the TIG welding process using computer-aided engineering (CAE) software.

CO 3	**Make use of different types of welding techniques for Industrial Applications.**
	1. Preparation of LAP JOINT using Arc Welding Process . 2. Preparation of LAP JOINT using Arc Welding Process for different size. **Try** 1. Preparation of BUTT JOINT using Arc Welding Process. 2. To simulate and analyze the arc welding process using computer-aided engineering (CAE) software.
CO 4	**Analyze various defects during gas welding, arc welding process and their causes and remedies.**
	1. Making of flange mould using a given pattern. 2. Utilizing the provided pattern, create the bearing housing mould. **Try** 4.1 Making of dumble using a given pattern. 4.2 Using a single-piece pattern, create a one-stepped shaft .
CO 5	**Demonstrate working principle of various sheet metal forming process such as Hydraulic press, deep drawing and bending operation.**
	1. To perform blanking and piercing operations and determine the punching force and blanking force theoretically. 2. To perform blanking and piercing operations and determine the punching force and blanking force theoretically . **Try** 1. Prepare blanking and piercing operations on different materials. 2. To design a progressive die using CAD software, focusing on creating a series of operations that transform a metal strip into a finished part, with multiple stages in a single die.
CO 6	**Demonstrate the various process in making of plastic components for engineering / domestic applications.**
	1. Perform injection moulding operation for given plastic raw material 2. Perform injection moulding operation for given plastic raw material **Try** 1. Perform the Moulding for mixer grinder from a circuit board. 2. To design and simulate an injection mold using CAD software, ensuring that the mold will produce high-quality parts efficiently and reliably.

TEXTBOOKS

1. S.K.Hajra Choudhury, A.K.Hajra Choudhury A.K. and S.K.Nirjhar Roy, "*Elements of Workshop Technology*", Media promoters and publishers private limited, Mumbai, 4th Edition ,2020.
2. S.Kalpakjian, Steven S. Schmid, "*Manufacturing Engineering and Technology*", Pearson Education India Edition, 7th Edition, 2019.

REFERENCE BOOKS:

1. Gowri P. Hariharan, A. Suresh Babu, "*Manufacturing Technology – I*", Pearson Education,5thEdition , 2018.
2. Roy A. Lindberg, "*Processes and Materials of Manufacture*", Prentice Hall India, 4th Edition, 2017.

MATERIALS ONLINE:

1. Lab manual
2. Question bank

19. 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	R1:11.1-11.5
2	Sand properties testing for strengths and permeability.	CO 1	R1:4.8,R1:7.2
3	Moulding, melting and casting.	CO 1	R1:6.3-6.52
4	Arc welding lap and butt joint	CO 2	R1:10.1-10.2
5	Spot welding, TIG welding.	CO 2	R2:12.6, R1:5.2
6	Brazing.	CO 3	R1:9.3-9.5
7	Blanking and piercing operations.	CO 4	R2:10.4-10.7
8	Study of simple, compound and progressive press tool	CO 4	R2:3.12
9	Hydraulic press: deep drawing and extrusion operation	CO 5	R1:2.18
10	Bending and other operation	CO 6	R2:13.8 - 13-11
11	Injection moulding.	CO 6	R2:14.2-14-6
12	Blow moulding.	CO 6	R1:17.4-17-5
13	Riveting of a plates.	CO 6	R1:15.3-15-5
14	Demonstration of progressive die machine.	CO 6	R2:9.5-9-7

20. Experiments for enhanced learning (EEL):

S.No	Product Oriented Experiments
1	**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.
2	**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 location.
3	**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.
4	**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.

21. Program Outcomes and Program Specific Outcomes:

Program Outcomes

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

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

22. 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
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.	3	Lab Exercises
PO 6	**The Engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	Lab Exercises
PO 7	**Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	3	Lab Exercises

PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	1	Lab Exercises
PO 9	**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	1	Lab Exercises
PO 12	**Life-Long Learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change..	1	Lab Exercises / CIE /SEE

23. 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	Lab Exercises / CIE / SEE
PSO 3	Make use of computational and experimental tools for building career paths towards innovation startups, employability and higher studies.	3	Lab Exercises / CIE / SEE

3 = High; 2 = Medium; 1 = Low

24. 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	✓	-	-	-	✓	-	✓	-	-	-	-	✓	✓	-	✓

25. 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 science, mathematics and engineering fundamentals to select the proper tools and machines for making wood and metal works	3
	PO 6	Acquire the knowledge of maintaining safety regulations on the shop floor.	1
CO 2	PO 1	Apply the knowledge of mathematics and engineering fundamentals to develop rectangular trays and round tins.	2
	PO 6	Obtain knowledge about safety precautions in forging techniques.	1
CO 3	PO 1	Apply the basics of mathematics to measure the pipes and use engineering concepts for appropriate joints.	2
	PO 8	Acquire awareness of the norms of the engineering practice.	1
CO 4	PO 1	Apply the science and engineering knowledge to prepare the casting of complex shapes.	2
	PO 7	Understand the impact of professional engineering solutions in societal and environmental contexts.	2
CO 5	PO 1	Apply the science and engineering knowledge to make hard soldering in dissimilar materials.	2
	PO 6	Obtain knowledge about safety precautions in hard soldering techniques.	1
	PO 9	Function effectively as an individual and as a member in solder making of non ferrous/ ferrous materials.	1
CO 6	PO 1	Apply the science, mathematics and engineering knowledge to understand the concepts of digital manufacturing	3
	PO 5	Identify and select appropriate machines with modern techniques for the machining process.	1
	PO 7	Demonstrate their knowledge of recent trends in manufacturing, the need for sustainable development, and the impact of professional engineering solutions on society	2
	PO 12	Use life-long learning in the broadest context of recent trends in manufacturing domains.	1
	PSO 1	Attain knowledge and ideation towards digital manufacturing in product development and additive manufacturing techniques	2
	PSO 3	Make use of digital manufacturing demonstrations to build career paths towards employability and higher studies.	2

26. 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	-	-	-	-	-		-	-	-
CO 2	2	-	-	-	-	1	-	-	-	-	-	-	-	-	-
CO 3	2	-	-	-	-	-	-	1	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	2	-	-	-	-	-	-	-	-
CO 5	2	-	-	-	-	1	-	-	1	-	-	-	-	-	-
CO 6	3	-	-	-	1	-	2	-	-	-	-	1	2	-	2

27. Percentage of key competencies 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	-	-	-	-	20	-	-	-	-	-		-	-	-
CO 2	66	-	-	-	-	20	-	-	-	-	-	-	-	-	-
CO 3	66	-	-	-	-	-	-	33	-	-	-	-	-	-	-
CO 4	66	-	-	-	-	-	66	-	-	-	-	-	-	-	-
CO 5	66	-	-	-	-	20	-	-	8.3	-	-	-	-	-	-
CO 6	100	-	-	-	100	-	66	-	-	-	-	12.5	100	-	100

28. Course articulation matrix PO / PSO mapping:

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

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

2 - $40\ \% < C < 60\%$ –Moderate

1-5 $<C\leq 40\%$ – Low/ Slight

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

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

29. Assessment methodology -Direct:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

30. Assessment methodology -Indirect:

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

31. Relevance to Sustainability goals (SDGs):

Write brief description about the course and how its relevance to SDGs.

1	NO POVERTY	
2	ZERO HUNGER	
3	GOOD HEALTH AND WELL-BEING	
4	QUALITY EDUCATION	**Quality Education:** The engineering workshop course provides students with a strong foundation and allows them to apply knowledge about engineering tools used in manufacturing of products.
5	GENDER EQUALITY	

6	CLEAN WATER AND SANITATION	
7	AFFORDABLE AND CLEAN ENERGY	
8	DECENT WORK AND ECONOMIC GROWTH	
9	INDUSTRY, INNOVATION AND INFRASTRUCTURE	
10	REDUCED INEQUALITIES	
11	SUSTAINABLE CITIES AND COMMUNITIES	
12	RESPONSIBLE CONSUMPTION AND PRODUCTION	**Responsible Consumption and Production:** Focusing on efficient material use and waste reduction in engineering workshops can aid in the developing of components/products.
13	CLIMATE ACTION	
14	LIFE BELOW WATER	

15	LIFE ON LAND	
16	PEACE, JUSTICE AND STRONG INSTITUTIONS	
17	PARTNERSHIPS FOR THE GOALS	

Approved by: Board of Studies in the meeting conducted on 24.08.2023.

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

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE TEMPLATE

1	Department	**MECHANICAL ENGINEERING**			
2	Course Title	**DATA STRUCTURES LABORATORY**			
3	Course Code	ACSD08			
4	Program	B.Tech			
5	Semester	III Semester			
6	Regulation	BT-23			
7	Structure of the course	Practical			
		Tutorial Hours		Practical Hours	
		1		2	
8	Course Offered	Odd Semester ✓		Even Semester ×	
9	Course Coordinator	Mr. D. Atchuta Ramacharyulu			
10	Date Approved by BOS	25/08/2023			
11	Course Webpage	www.iare.ac.in/—-/—-			
12	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**
		UG	ACSD02	I	OPS with JAVA
		-	-	-	-

13. 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.

14. 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.

15. 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 finding effective solution of given problem.	Apply
CO 3	Construct programs to perform operations on linear data structures for memory organization of data.	Apply
CO 4	Make use of nonlinear data structures for solving real time applications.	Apply
CO 5	Demonstrate operations on Balanced Data Structures for efficient storage and retrieval of data.	Understand
CO 6	Choose suitable data structures based on implementation, operations and performance while solving real world problems.	Apply

16. Employability Skills

1. **Problem-Solving and Critical Thinking:** Students learn to analyze complex problems, design solutions using Java's object-oriented principles, and translate real-world scenarios into code.
2. **Debugging and Troubleshooting:** Debugging challenges in the lab help students master error identification, interpretation, and use of debugging tools, essential for real-world software development.

17. Content Delivery / Instructional Methologies:

✓	Day to Day lab evaluation	✓	Demo Video	✓	Expected Viva Voce questions	✓	Open Ended Experiments
X	Competitions	X	hackathons	✓	Certifications	✓	Probing Further Questions

18. Evaluation Methodology:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 3: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

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.

Table 4: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
					20

Table 5: Programming based

Objective	Analysis	Program	Results	Viva voce	Total
4	4	6	4	2	20

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

19 COURSE CONTENT

CO 1	**Interpret the complexity of algorithm using the asymptotic notations.**
	1. Getting Started Exercises
CO 2	**Select appropriate searching and sorting technique for finding effective solution of given problem.**
	1. Exercises on Searching 2. Exercises on Sorting 3. Exercises on Divide and Conquer
CO 3	**Construct programs to perform operations on linear data structures for memory organization of data.**
	1. Exercises Stack Data Structures 2. Exercises on Queue Data Structures 3. Exercises on Linked Lists 4. Exercises on Circular and Doubly Linked Lists
CO 4	**Make use of nonlinear data structures for solving real time applications.**
	1. Exercises on Trees 2. Exercises on BST
CO 5	**Demonstrate operations on Balanced Data Structures for efficient storage and retrieval of data.**
	1. Exercises on AVL Trees 2. Exercises on Graph Traversal
CO 6	**Choose suitable data structures based on implementation, operations and performance while solving real world problems.**
	1. Exercises on Data Structures based Applications 2. Exercises on Minimum Cost Spanning Tree

Note: One Course Outcome may be mapped to multiple number of experiments.

TEXTBOOKS

1. Mark Allen Weiss,"*Data Structures and Problem Solving using Java*", Pearson Fourth Edition.

2. Michael T. Goodrich and Roberto Tamassia "*Data Structures and Algorithms in Java*" , John Wiley Sons, Inc., Fourth Edition

REFERENCE BOOKS:

1. Deitel, Paul and Deitel, Harvey. "*Java: How to Program*", Pearson, 11th Edition,2018.
2. Evans, Benjamin J. and Flanagan, David. "*Java in a Nutshell*", O'Reilly Media, 7th Edition, 2018.

MATERIALS ONLINE:

1. https://www.codechef.com/certification/data-structures-and-algorithms/prepare
2. https://www.geeksforgeeks.org/java
3. https://www.tutorialspoint.com/java/index.htm
4. https://online-learning.harvard.edu/course/data-structures-and-algorithms

20.COURSE PLAN:

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

S.No	Topics to be covered	CO's
1	Getting Started Exercises	CO 1
2	Exercises on Searching	CO 2
3	Exercises on Sorting	CO 2
4	Exercises onDivide and Conquer	CO 2
5	Exercises on Stacks	CO 3
6	Exercises on Queues	CO 3
7	Exercises on Linked Lists	CO 3
8	Exercises on Circular and Doubly Linkde Lists	CO 3
9	Exercises on Trees	CO 4
10	Exercise on BST	CO 4
11	Exercises on AVL trees	CO 5
12	Exercises on Graph Traversal Techniques	CO 4
13	Exercises on Spanning Trees	CO 6

Experiments for enhanced learning (EEL):

S.No	Design Oriented Experiments
1.	Write a function to determine if two trees are identical or not: (Two trees are identical when they have the same data and the arrangement of data is also the same)
2.	Given a binary search tree, task is to find Kth largest element in the binary search tree.
3.	Ind Strongly Connected Components (SCCs) of Given Graph G. .
4.	Given an array of pairs, find all symmetric pairs in it. (wo pairs (a, b) and (c, d) are said to be symmetric if c is equal to b and a is equal to d. For example, (10, 20) and (20, 10) are symmetric. Given an array of pairs find all symmetric pairs in it)
5.	Find distance between two nodes of a Binary Tree.

21. PROGRAM OUTCOMES & PROGRAM SPECIFIC 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
Program Specific Outcomes	
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.

Program Outcomes	
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.

22. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	LAB PROGRAMS/ 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 PROGRAMS/ 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	LAB PROGRAMS/ 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	LAB PROGRAMS/ 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.	3	LAB PROGRAMS/ CIE/SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	Viva voce /CIE/SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	1	Viva Voce/ CIE/SEE

23. 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.	1	LAB PROGRAMS/CIE/SEE

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOME	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	✓	✓	✓	✓	✓	-	-	-	-	✓	-	✓	-	-	✓

25. 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
CO1	PO 1	**Understand** (knowledge) the concept of Algorithm Analysis and Types of Notations used to represent Time and Space Complexities (Understand) by applying principles of **mathematics** 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
	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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	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
	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
	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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
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
	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
	PSO3	**Build** sufficient knowledge hashing techniques and collision resolution methods so that new product can be developed, which leads to become successful entrepreneur in the present market.	1

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
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 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

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

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

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

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

28. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

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

29. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

30. ASSESSMENT METHODOLOGY INDIRECT:

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

31. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

X	NO POVERTY	
X	ZERO HUNGER	
X	GOOD HEALTH AND WELL-BEING	
✓	QUALITY EDUCATION	**Quality Education:** The students can gain a deeper understanding of how technology can be harnessed to address global challenges. This promotes quality education by fostering critical thinking and problem-solving skills in the context of sustainable development.
X	GENDER EQUALITY	
X	CLEAN WATER AND SANITATION	
X	AFFORDABLE AND CLEAN ENERGY	
X	DECENT WORK AND ECONOMIC GROWTH	

✓	INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Industry, Innovation, and Infrastructure:** Java programming skills are essential for developing innovative software solutions. Students working on projects related to sustainable development can contribute to building resilient infrastructure and promoting inclusive and sustainable industrialization.
X	REDUCED INEQUALITIES	
✓	SUSTAINABLE CITIES AND COMMUNITIES	**Sustainable Cities and Communities:** Java programming plays a crucial role in developing applications for smart cities, efficient transportation, and waste management systems. Through projects in the lab, students can explore ways to create more sustainable urban environments.
X	RESPONSIBLE CONSUMPTION AND PRODUCTION	
✓	CLIMATE ACTION	**Climate Action:** Students can create climate-related applications, such as carbon footprint calculators or climate data analysis tools, using Java programming. This directly contributes to SDG 13 by raising awareness and facilitating climate action.
X	LIFE BELOW WATER	
X	LIFE ON LAND	
✓	PEACE, JUSTICE AND STRONG INSTITUTIONS	**Peace, Justice, and Strong Institutions:** Java programming skills can be applied to create tools for transparency, accountability, and data security. By focusing on ethical coding practices, the lab can contribute to strong and just institutions.

✓		**Partnerships for the Goals:** Collaborative projects can foster partnerships among students, educators, and local communities. These partnerships enhance knowledge sharing and the development of innovative solutions that align with multiple SDGs.

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD,ME**
D. Atchuta Ramacharyulu, Assistant Professor