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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**ENGLISH**				
Course Code	AHSB01				
Program	B. Tech				
Semester	I				
Course Type	Foundation				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	-	2	-	-
Course Coordinator	Dr. M.Sailaja, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

II COURSE OVERVIEW:

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

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

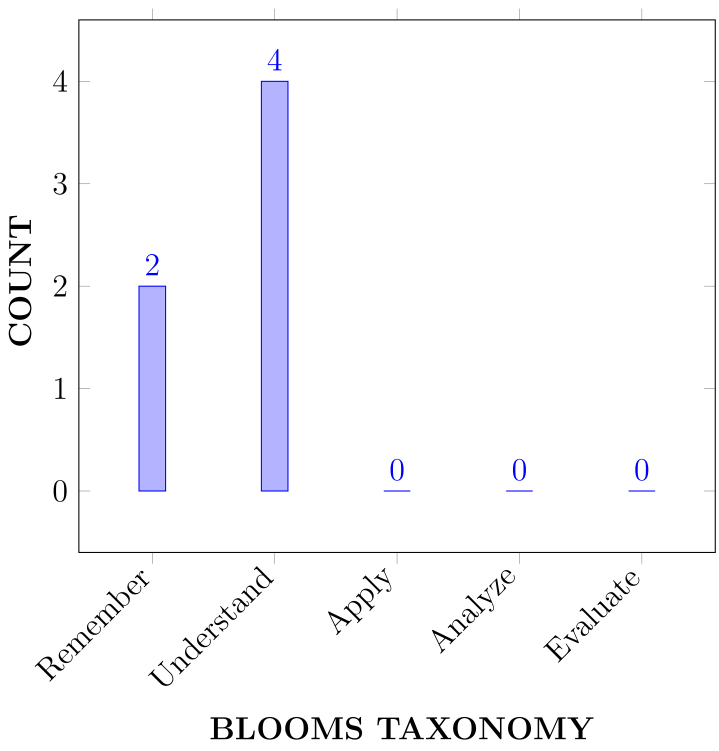
I	Communicate in an intelligible English pronunciation to meet the global standards.
II	Effectively use of four language skills (listening skill, speaking skill, reading skill and writing skill) in day-to-day affairs.
III	A critical aspect of speaking and reading for interpreting in-depth meaning between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

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 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	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	

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

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

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 $<C \leq 40\%$ – Low/ Slight

2 - 40 % $<C < 60\%$ –Moderate

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

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

TEXTBOOKS

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

REFERENCE BOOKS:

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

XIX COURSE PLAN:

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

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

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

64	Honesty, Respect, Self-Control and Accountability their role in building long lasting interpersonal skills?	CO 3	TI: 9,10
65	Etiquette and manners. Its importance in social, personal and professional communication.	CO 23	TI: 9,10
66	Problem solving and decision making.	CO 3	TI: 9,10

Signature of Course Coordinator **HOD**

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

Course Title	**ENGLISH LANGUAGE AND COMMUNICATION SKILLS LABORATORY**				
Course Code	AHSB08				
Program	B.Tech				
Semester	I	AE			
Course Type	Foundation				
Regulation	R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Dr. Jetty Wilson, Professor				

I COURSE OVERVIEW:

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

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Sofware based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

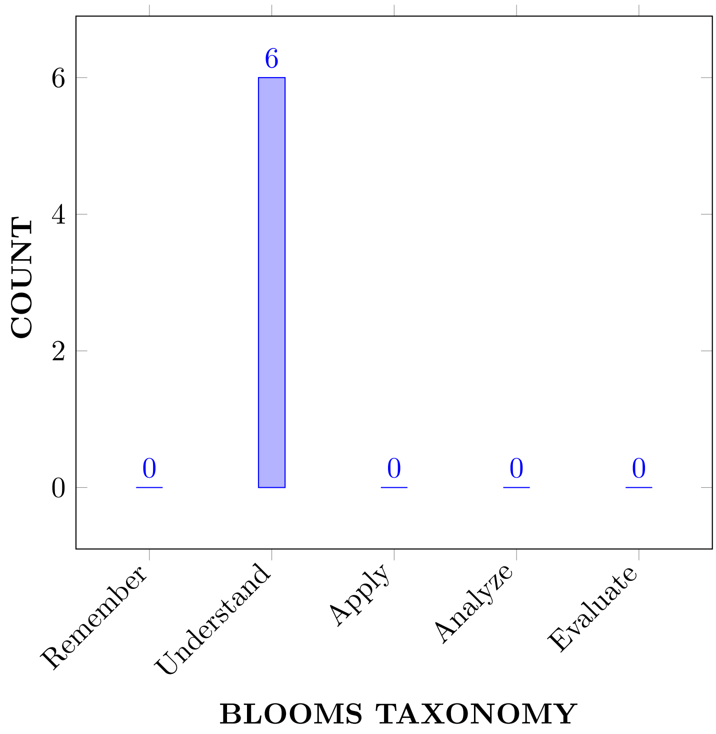
I	Facilitate computer-assisted multi-media instructions to make possible individualized and independent language learning.
II	The critical aspect of speaking and reading for interpreting in-depth meaning of the sentences.
III	Use language appropriately for social interactions such as public speaking,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

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Build the prototype of UAVs and aero-foil models for testing by using low speed wind tunnel towards research in the area of experimental aerodynamics.	-	-

PSO 2	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	-	-
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	-	-

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 10	Discuss the heeds of functional **grammar** and **punctuation** tools in **speaking** and **writing** by generating the **clarity** of an audio text.	5
CO 2	PO 9	Define the meaning of **individual work** and **team work** and also participate effectively to develop **leadership** qualities among the **diverse teams** in **multidisciplinary** settings.	5
CO 3	PO 10	Describe the **clarity** of **grammatical** usage and the obligation of **punctuation** marks in **speaking** and **writing**.	5
CO 4	PO 10	Choose suitable **grammatical** structures and **punctuation** marks at **speaking** and **writing** areas maintaining **clarity** at professional platform.	5
CO 5	PO 10	Interpret the **grammatical** knowledge and **punctuation** marks systematically towards providing the **clarity** in **speaking** and **writing**.	5
CO 6	PO 10	Demonstrate the role of **grammar** and **punctuation** marks understanding the meaning between the sentences as well as paragraphs in **speaking** or **writing** for a **clarity**.	5

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

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

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

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

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

TEXTBOOKS

1. ENGLISH LANGUAGE AND COMMUNICATION SKILLS: LAB MANUAL

REFERENCE BOOKS:

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

XV COURSE PLAN:

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

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

10	Common Errors In Pronunciation And Pronunciation Practice Through Tongue Twisters, Interpretation Of Proverbs And Idioms.	CO 2	R1:42-43
11	Lisening Comprehension, Etiquettes	CO 5	R1:44-48
12	Techniques And Methods To Write Summaries And Reviews Of Videos,Writing Messages, Leaflets And Notices Etc.	CO 4	R1:107-110
13	Common Errors, Resume Writing.	CO 4	R1:7.3
14	Introduction To Word Dictionary,Group Discussions – Video Recording – Feedback.	CO 5	R1:7.3
15	Introduction To Conversation Skills,Mock Interviews.	CO 6	R1: 54-58

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

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

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

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

COMPUTER SCIENCE AND ENGINEERING
COURSE DESCRIPTION

Course Title	**ENGINEERING CHEMISTRY LABORATORY**				
Course Code	AHSB09				
Program	B.Tech				
Semester	II	CSE			
Course Type	FOUNDATION				
Regulation	IARE – R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Mr G Mahesh Kumar, Assiatant Professor				

I COURSE OVERVIEW:

The aim of this Engineering Chemistry laboratory is to develop the analytical ability of the students by better understanding the concepts experimental chemistry. The experiments carried out like preparation of aspirin, thiokol rubber, conductometry, potentiometry, physical properties like viscosity and surface tension of liquids. The volumetric analytical experiments like determination of hardness of water, dissolved oxygen and copper in brass can be carried out in the laboratory.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
10+2	-	-	Basic principles of chemistry laboratory	-

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Engineering Workshop Practice	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

The emphasis on the experiments is broadly based on the following criteria given in Table: 1

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

A. Experiment Based

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

B. Programming Based

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

VI COURSE OBJECTIVES:

The students will try to learn:

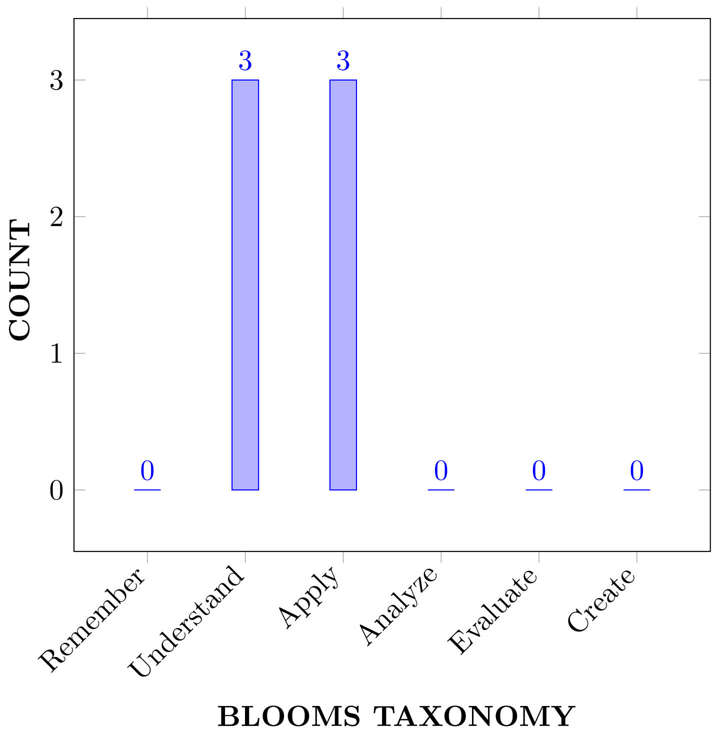
I	The basic principles involved in chemical analysis and mechanism of synthetic organic reactions. processes.
II	The need and importance of quality of water for industrial and domestic use..
III	The measurement of physical properties like surface tension and viscosity.
IV	The knowledge on existing future upcoming devices, materials and methodology.

VII COURSE OUTCOMES:

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

CO 1	**Identify** Explain the mechanism of chemical reactions for synthesizing drug molecules. for making a desired product with given work piece.	Understand
CO 2	**Determine** Identify the total hardness, dissolved oxygen in water by volumetric analysis for finding the hardness causing salts in water. to demonstrating proficiency with hand tools common in fitting.	Apply
CO 3	**Create** Make use of conductometric and potentiometric titrations for finding the concentration of unknown solutions.to convert given shape into useable elements using basic blacksmith techniques.	Apply
CO 4	**Organize** the moulding techniques along with suitable tools Choose different types of liquids for finding the surface tension and viscosity of lubricants.	Apply
CO 5	**Develop** Explain the preparation of synthetic rubbers for utilizing in industries and domestic purpose. for manufacturing the tin boxes, cans, funnels, ducts etc., from a flat sheet of metal.	Understand
CO 6	**Compare** various electrical circuits by using conduit system of wiring Relate the importance of different types of materials for understanding their composition and applications.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	-	SEE/CIE
PO 2	**Design/development of solutions:** 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	-	SEE/CIE
PO 7	**Modern tool usage:** 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.	-	SEE/CIE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	-	-
PSO 2	Focus on ideation and research towards product development using additive manufacturing, CNC simulation and high speed machining. .	-	-
PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	-	-

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Explain the mechanism of chemical reactions for synthesizing drug molecules by applying mathematical expressions for finding the percentage of Aspirin by using principles of science for solving engineering problems.	3

CO 2	PO 1	Demonstrate the total hardness, dissolved oxygen in water by volumetric analysis for finding the hardness causing salts in water by applying mathematical expressions 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	Identify the dissolved oxygen content in raw water and reduce the pollutants in atmosphere to protect aquatic organisms and know the impact in socio economic and environmental contexts for sustainable development..	2
CO 3	PO 1	Choose different electrodes for finding pH of unknown solutions by applying mathematical expressions of cell potential by using principles of science for solving engineering problems.	3
	PO 2	Identify the problem formulation and abstraction for calculating the concentration of unknown solutions by applying normality of standard solution from the provided information.	2
CO 4	PO 1	Choose different types of liquids for finding the surface tension and viscosity of lubricants by applying mathematical expressions by using principles of science for solving engineering problems..	3
	PO 2	Identify the problem formulation and abstraction for calculating viscosity and surface tension of test liquids by applying viscosity and surface tension of standard liquids, density of liquids from the provided information.	2
CO 5	PO 1	Explain the preparation of synthetic rubbers for utilizing in industries and domestic purpose by using principles of science for solving engineering problems.	2
CO 6	PO 1	Demonstrate the percentage of copper in brass, manganese dioxide in pyrolusite by volumetric analysis using mathematical expressions by using principles of science for solving engineering problems. .	3

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

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

3 = High; 2 = Medium; 1 = Low

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1, PO 2,	SEE Exams	PO 1,PO 2, PO 7,	Seminars	-
Laboratory Practices	PO 1,PO 2, PO 7,	Student Viva	PO 1, PO 5	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK 1	**PREPARATIONS OF ORGANIC COMPOUNDS**
	Preparation of Aspirin
WEEK 2	**VOLUMETRIC ANALYSIS**
	Estimation of hardness of water by EDTA method
WEEK 3	**CONDUCTOMETRIC TITRATIONS**
	Conductometric titration of strong acid Vs strong base
WEEK 4	**POTENTIOMETRIC TITRATIONS**
	Potentiometric titration of strong acid Vs strong base
WEEK 5	**CONDUCTOMETRIC TITRATIONS**
	Conductometric titration of mixture of acid Vs strong base
WEEK 6	**POTENTIOMETRIC TITRATIONS**
	Potentiometric titration of weak acid Vs strong base .
WEEK 7	**PHYSICAL PROPERTIES**
	Determination of surface tension of a given liquid using stalagmometer
WEEK 8	**PHYSICAL PROPERTIES**
	Determination of viscosity of a given liquid by using Ostwald's viscometer
WEEK 9	**VOLUMETRIC ANALYSIS**
	Estimation of dissolved oxygen in water
WEEK 10	**PREPARATIONS OF RUBBER**
	Preparation of Thiokol rubber .

WEEK 11	**VOLUMETRIC ANALYSIS**
	Determination of percentage of copper in brass. .
WEEK 12	**VOLUMETRIC ANALYSIS**
	Estimation of MnO 2 in pyrolusite .

TEXTBOOKS

1. Vogel's, "Quantitative Chemical Analaysis", Prentice Hall, 6th Edition, 2000.
2. Gary D.Christian, "Analytical Chemistry",Wiley India, 6th Edition, 2007.

REFERENCE BOOKS:

1. A text book on experiments and calculation Engg. S.S. Dara.
2. Instrumental methods of chemical analysis, Chatwal, Anand, Himalaya Publications

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Preparation of Aspirin.	CO 1, CO 2	R1, R2
2	Estimation of hardness of water by EDTA method.	CO 2	R1, R2
3	Conductometric titration of strong acid Vs strong base	CO 3,	R1, R2
4	Potentiometric titration of strong acid Vs strong base.	CO 3	R1, R2
5	Conductometric titration of mixture of acid Vs strong base	CO 3	R1, R2
6	Potentiometric titration of weak acid Vs strong base	CO 3	R1, R2
7	Determination of surface tension of a given liquid using stalagmometer	CO4	R1, R2
8	Determination of viscosity of a given liquid by using Ostwald's viscometer	CO4	R1, R2
9	Estimation of dissolved oxygen in water	CO 2	R1, R2
10	Preparation of Thiokol rubber	CO 5	R1, R2
11	Determination of percentage of copper in brass.	CO 6	R1, R2
12	Estimation of MnO 2 in pyrolusite	CO6	R1, R2

Signature of Course Coordinator **HOD,CSE**
Mr G Mahesh Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COMPUTER SCIENCE AND ENGINEERING

COURSE DESCRIPTION

Course Title	**PROGRAMMING FOR PROBLEM SOLVING LABORATORY**				
Course Code	ACSB02				
Program	B.Tech				
Semester	II	CSE |IT |ECE |EEE |MECH |AERO			
Course Type Regulation	Foundation IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. P Ravinder, Assistant Professor				

I COURSE OVERVIEW:

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

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	ACSB02	I	-

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

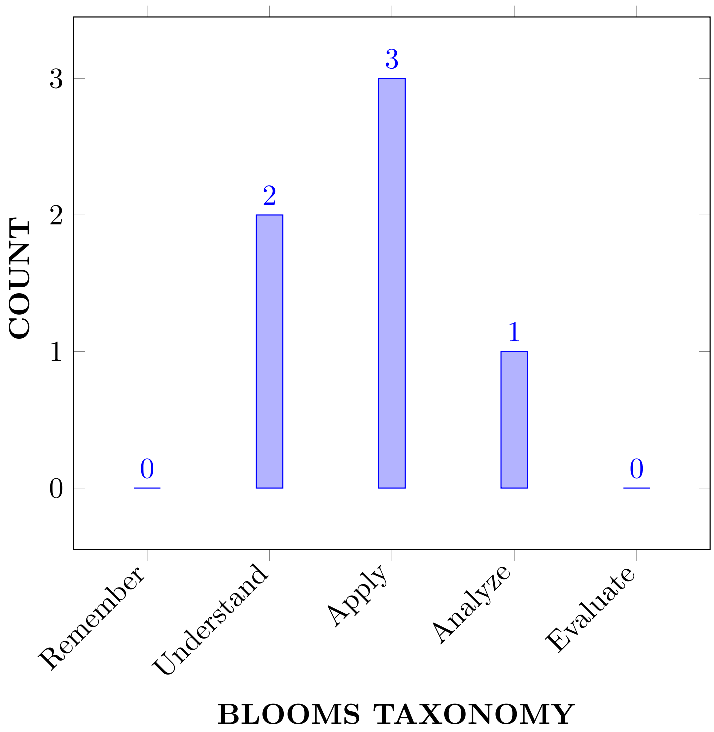
I	The hands on experience in design, develop, implementation and evaluation by using Asymptotic notation.
II	The demonstration knowledge of basic abstract data types (ADT) and associated algorithms for organizing programs into modules using criteria that are based on the data structures of the program.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

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:**Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Viva-voce/Laboratory Practices
PO 2	**Problem analysis:**Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Viva-voce/Laboratory Practices
PO 3	**Design/development of solutions:**Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	Viva-voce/Laboratory Practices
PO 5	**Modern Tool Usage:**Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	2	Viva-voce/Laboratory Practices

PO 10	**Communication:**Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Viva-voce/Laboratory Practices
PO 12	**Life-long learning:**Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	Viva-voce/Laboratory Practices

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	**Professional Skills:** The ability to research, understand and implement computer programs in the areas related to algorithms, system software, multimedia, web design, big data analytics, and networking for efficient analysis and design of computer-based systems of varying complexity. .	2	Viva-voce Laboratory Practices
PSO 2	**Software Engineering Practices:** The ability to apply standard practices and strategies in software service management using open-ended programming environments with agility to deliver a quality service for business success .	2	Viva-voce Laboratory Practices
PSO 3	**Successful Career and Entrepreneurship:** The ability to employ modern computer languages, environments, and platforms in creating innovative career paths, to be an entrepreneur, and a zest for higher studies. .	2	Viva-voce Laboratory Practices

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Understand (knowledge) the basic concept of algorithm analysis which provides theoretical estimates for the resources needed by any algorithm for a given computational problem. These estimates provide an insight into reasonable directions of search for efficient algorithms by applying the principles of **mathematics and science**	3

	PO 5	Understand the (given **knowledge**) appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	3
CO 2	PO 1	Understand (knowledge)the basic concept of algorithm analysis which provides theoretical estimates for the resources needed by any algorithm for a given computational problem. These estimates provide an insight into reasonable directions of search for efficient algorithms by applying the principles of **mathematics and science.**	3
	PO 5	Understand the (**knowledge**) appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	2
CO 3	PO 1	Understand (**knowledge**) the basic concept of algorithm analysis which provides theoretical estimates for the resources needed by any algorithm for a given computational problem. These estimates provide an insight into reasonable directions of search for efficient algorithms by applying the principles of **mathematics and science.**	3
	PO 5	Understand the (knowledge) appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	3
CO 4	PO 1	Describe (knowledge) the use sorting techniques as a basic building block in algorithm design and problem solving **using principles of mathematics, science, and engineering fundamentals.**	3
	PO 5	Understand the **knowledge** appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	2
	PO 10	Apply (knowledge) concept of dimensional analysis and similarity parameters for predicting physical parameters (understanding) for the fluid flow analysis used in designing prototypes devices (apply) solving design problems by applying the **communicating effectively with engineering community.**	3
CO 5	PO 1	Outline the importance of searching algorithms to retrieve an element from any data structure where it is stored by **understanding and applying the fundamentals of mathematics, science and engineering.**	3
	PO 10	Understand the use of searching techniques that retrieve information stored within some data structure by **communicating effectively with engineering community**.	2

CO 6	PO 1	Outline the importance of searching algorithms to retrieve an element from any data structure where it is stored by **understanding and applying the fundamentals of mathematics, science and engineering**	2
	PO 10	Understand the use of searching techniques that retrieve information stored within some data structure by **communicating effectively with engineering communit.**	3

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

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

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**OPERATORS AND EVALUATION OF EXPRESSIONS**
	a. Write a C program to check whether a number is even or odd using ternary operator. b. Write a C program to perform the addition of two numbers without using + operator. c. Write a C program to evaluate the arithmetic expression ((a + b / c * d - e) * (f - g)). Read the values a, b, c, d, e, f, g from the standard input device. d. Write a C program to find the sum of individual digits of a 3 digit number. e. Write a C program to read the values of x and y and print the results of the following expressions in one line: i. (x + y) / (x - y) ii. (x + y)(x - y)
WEEK II	**CONTROL STRUCTURES**
	a. Write a C program to find the sum of individual digits of a positive integer. b. A Fibonacci sequence is defined as follows: The first and second terms in the sequence are 0 and 1.Subsequent terms are found by adding the preceding two terms in the sequence. Write a C program to generate the first n terms of the sequence. c. Write a C program to generate all the prime numbers between 1 and n, where n is a value supplied by the user. d. A character is entered through keyboard. Write a C program to determine whether the character entered is a capital letter, a small case letter, a digit or a special symbol using if- else and switch case. The following table shows the range of ASCII values for various characters. Characters ASCII values A – Z 65 – 90 a – z 97 – 122 0 – 9 48 – 57 Special symbols 0 – 47, 58 – 64, 91 – 96, 123 – 127 If cost price and selling price of an item is input through the keyboard, write a program to determine whether the seller has made profit or incurred loss. Write a C program to determine how much profit or loss incurred in percentage.
WEEK III	**CONTROL STRUCTURES**
	a. Write a C program to find the roots of a quadratic equation. d. Write a C program to check whether a given 3 digit number is Armstrong number or not. e. Write a C program to print the numbers in triangular form 1 1 2 1 2 3
WEEK IV	**ARRAYS**
	a. Write a C program to find the second largest integer in a list of integers. b. Write a C program to perform the following: i. Addition of two matrices ii. Multiplication of two matrices c. Write a C program to count and display positive, negative, odd and even numbers in an array. d. Write a C program to merge two sorted arrays into another array in a sorted order. e. Write a C program to find the frequency of a particular number in a list of integer.
WEEK V	**STRINGS**

	a. Write a C program that uses functions to perform the following operations: i. To insert a sub string into a given main string from a given position. ii. To delete n characters from a given position in a given string. b. Write a C program to determine if the given string is a palindrome or not. c. Write a C program to find a string within a sentence and replace it with another string. d. Write a C program that reads a line of text and counts all occurrence of a particular word. e. Write a C program that displays the position or index in the string S where the string T begins, or 1 if S doesn't contain T. .
WEEK VI	**FUNCTIONS**
	a. Write C programs that use both recursive and non-recursive functions i. To find the factorial of a given integer. ii. To find the greatest common divisor of two given integers. b. Write C programs that use both recursive and non-recursive functions i. To print Fibonacci series. ii. To solve towers of Hanoi problem. c. Write a C program to print the transpose of a given matrix using function. d. Write a C program that uses a function to reverse a given string. .
WEEK VII	**POINTERS**
	a. Write a C program to concatenate two strings using pointers. b. Write a C program to find the length of string using pointers. c. Write a C program to compare two strings using pointers. d. Write a C program to copy a string from source to destination using pointers. e. Write a C program to reverse a string using pointers. .
WEEK VIII	**STRUCTURES AND UNIONS**
	a. Write a C program that uses functions to perform the following operations: i. Reading a complex number ii. Writing a complex number iii. Addition and subtraction of two complex numbers iv. Multiplication of two complex numbers. Note: represent complex number using a structure. b. Write a C program to compute the monthly pay of 100 employees using each employee's name, basic pay. Print the employees name and gross salary. c. Create a Book structure containing book id, title, author name and price. Write a C program to pass a structure as a function argument and print the book details. d. Create a union containing 6 strings: name, home address, hostel address, city, state and zip. Write a C program to display your present address. e. Write a C program to define a structure named DOB, which contains name, day, month and year. Using the concept of nested structures display your name and date of birth. .
WEEK IX	**ADDITIONAL PROGRAMS**

	a. Write a C program to read in two numbers, x and n, and then compute the sum of this geometric progression: 1+x+x2+x3+… +xn . For example: if n is 3 and x is 5, then the program computes1+5+25+125. Print x, n, the sum. Perform error checking. For example, the formula does not make sense for negative exponents if n is less than 0. Have your program print an error message if n¡0, then go back and read in the next pair of numbers of without computing the sum. Are any values of x also illegal? If so, test for them too. b. 2s complement of a number is obtained by scanning it from right to left and complementing all the bits after the first appearance of a 1. Thus 2's complement of 11100 is 00100. Write a C program to find the2 s complement of a binary number. c. Write a C program to convert a Roman numeral to its decimal equivalent. E.g. Roman number CD is equivalent to 400. .
WEEK X	**PREPROCESSOR DIRECTIVES**
	a. Define a macro with one parameter to compute the volume of a sphere. Write a C program using this macro to compute the volume for spheres of radius 5, 10 and 15 meters. b. Define a macro that receives an array and the number of elements in the array as arguments. Write a C program for using this macro to print the elements of the array. c. Write symbolic constants for the binary arithmetic operators +, -, *, and /. Write a C program to illustrate the use of these symbolic constants.
WEEK XI	**FILES**
	a. Write a C program to display the contents of a file. b. Write a C program to copy the contents of one file to another. c. Write a C program to reverse the first n characters in a file, where n is given by the user. d. Two files DATA1 and DATA2 contain sorted lists of integers. Write a C program to merge the contents of two files into a third file DATA i.e., the contents of the first file followed by those of the second are put in the third file. e. Write a C program to count the no. of characters present in the file
WEEK XII	**COMMAND LINE ARGUMENTS**
	a. Write a C program to read arguments at the command line and display it. b. Write a C program to read two numbers at the command line and perform arithmetic operations on it. c. Write a C program to read a file name at the command line and display its contents.

TEXTBOOKS

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

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

REFERENCE BOOKS:

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

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

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

XV COURSE PLAN:

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

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

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

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

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

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

COURSE DESCRIPTION

Department	**COMPUTER SCIENCE AND ENGINEERING**				
Course Title	PROGRAMMING FOR PROBLEM SOLVING USING C				
Course Code	ACSB01				
Program	B.Tech				
Semester	II				
Course Type	FOUNDATION				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. P Ravinder, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	-	-	Basic Programming Concepts

II COURSE OVERVIEW:

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

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
20%	Remember
30%	Understand
50%	Apply
0 %	Analyze

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

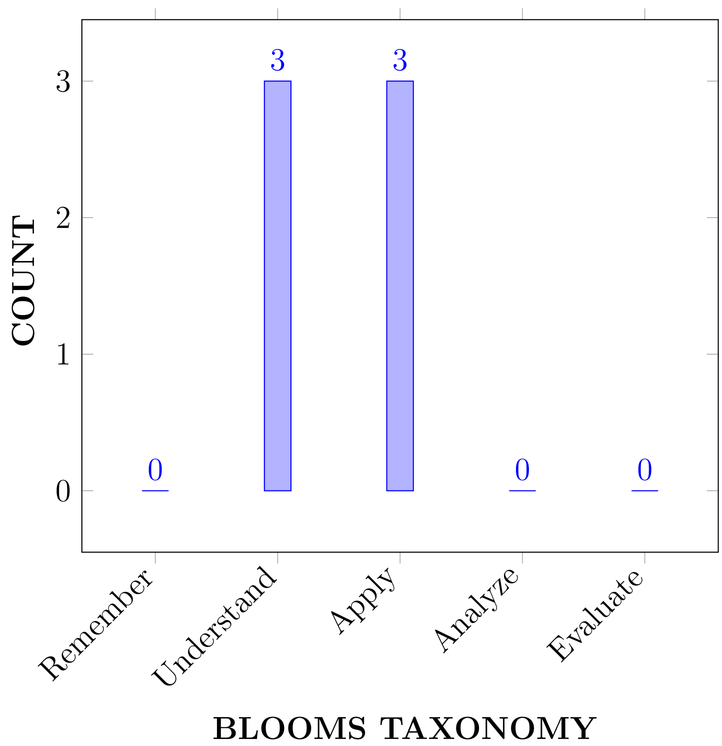
I	Learn adequate knowledge by problem solving techniques.
II	Understand programming skills using the fundamentals and basics of C Language.
III	Improve problem solving skills using arrays, strings, and functions.
IV	Understand the dynamics of memory by pointers.
V	Study files creation process with access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

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Understand, design and analyze computer programs in the areas related to problem solving through programming.	2	Tech talk/Open ended experiments
PSO 2	Make use of modern computer tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2	Tech talk/Open ended experiments

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Developing algorithms and draw flowcharts for solving **mathematical** and **engineering problems** related to **areas of computer science.**	3
	PO 2	Understand the various symbols to **draw** a flowchart, **identify** the appropriate symbols to solve a problem, then **formulate** the solution, and **interpret** the result for the **improvement** of the **solution.**	6
	PSO 1	Understand the features of procedural programming for **designing** and **analyzing** computer programs for **problem-solving.**	3
CO 2	PO 1	Understand branching statements, loop statements, and apply the fundamentals of **mathematics**, **science** and **engineering**.	3
	PO 2	Understand the **problem statement**, **control** the flow of data, **design** the solution and **analyze** the same to **validate** the results in a program to solve **complex** engineering problems.	6
	PO 3	**Recognize** an appropriate control structure to **design** and **develop** a solution for a **real-time** scenario, and **communicating** effectively with engineering community.	5
CO 3	PO 1	Recognize the importance of recursionfor developing programs in real-time scenarios using principles of **mathematics**, and **engineering fundamentals**.	3
	PO 2	Understand the various kinds of **functions**, **identify** the suitable type of function to **solve** a problem, **formulate** the solution, and **interpret** the result for the **improvement** of the solution.	6
	PO 5	Apply techniques of **structured decomposition** to dividea problem into smaller pieces with an understanding of its limitations.	1

CO 4	PO 1	Extend the focus on the usage of heterogeneous data types as a **basic building block** in problem solving using principles of **science**, and **engineering** fundamentals.	3
	PO 2	**Recognize** the representation of the structure, **assess** in solving a problem, **express the solution**, and **analyze** the result for **solution enhancement**.	5
	PO 5	Understand pointers conceptually and apply them in modeling a **complex engineering** activity.	1
CO 5	PO 1	Make a use of an appropriate type of file to store a large volume of **persistent data** and give solution to **engineering problems**.	2
	PO 5	To identify appropriate mode to access a file and run the same **program** multiple times.	1
CO 6	PO 12	**Realize** the need and the desire to **train** and **invest** in autonomous and **lifelong learning** in the widest sense of **technical transition** to achieve **employability expertise** and excel advanced **engineering concepts**.	7
	PSO 3	Attain the **knowledge** and **skills** for employability and to succeed in national and international level **competitive examinations**.	3

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	60	-	-	-	-	-	-	-	-	-	-	50	-	-
CO 2	100	60	50	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	60	-	-	100	-	-	-	-	-	-	-	-	-	-
CO 4	100	50	-	-	100	-	-	-	-	-	-	-	-	-	-
CO 5	66	-	-	-	100	-	-	-	-	-	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	-	-	58	-	-	50

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 2	3	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	3	-	-	3	-	-	-	-	-	-	-	-		-
CO 4	3	2	-	-	3	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	3	-	-	-	-	-	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	-	-	2	-	-	2
TOTAL	15	11	2	-	9	-	-	-	-	-	-	2	2	-	2
AVERAGE	3	2.7	2.5	-	3	-	-	-	-	-	-	2	2	-	2

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	INTRODUCTION
	Introduction to components of a computers: Introduction to Programming: Computer system, components of a computer system, computing environments, computer languages, creating and running programs, algorithms, flowcharts;**Introduction to C Language:** Computer languages, History of C, basic structure of C programs, process of compiling and running a C program, C tokens, keywords, identifiers, constants, strings, special symbols, variables, data types; Operators and expressions.

MODULE II	**CONTROL STRUCTRES**
	Conditional Control structures: Decision statements; Simple if, if-else, else if ladder, Nested if and Case Statement-switch statement; **Loop control statements:** while, for and do while loops. jump statements, break, continue, goto statements;
MODULE III	**ARRAYS AND FUNCTIONS**
	Arrays: Need for user defined functions, function declaration, function prototype, category of functions, inter function communication, function calls, parameter passing mechanisms, recursion, passing arrays to functions, passing strings to functions, storage classes, preprocessor directives; **Functions:** Need for user defined functions, function declaration, function prototype, category of functions, inter function communication, function calls, parameter passing mechanisms, recursion, passing arrays to functions, passing strings to functions, storage classes, preprocessor directive.
MODULE IV	**STRUCTURES, UNIONS AND POINTERS**
	Structures and unions: Structure definition, initialization, accessing structures, nested structures, arrays of structures, structures and functions, passing structures through pointers, self-referential structures, unions, bit fields, typedef, enumerations; **Pointers:**Pointer basics, pointer arithmetic, pointers to pointers, generic pointers, array of pointers, pointers and arrays, pointers as functions arguments, functions returning pointers.**Dynamic memory allocation:**Basic concepts, library functions.
MODULE V	**FILE HANDLING AND BASIC ALGORITHMS**
	Files: Streams, basic file operations, file types, file opening modes, input and output operations with files, special functions for working with files, file positioning functions, command line arguments. Searching, basic sorting algorithms (bubble, insertion, selection), algorithm complexity through example programs (no formal definitions required).

TEXTBOOKS

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

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

REFERENCE BOOKS:

1. W. Kernighan Brian, Dennis M. Ritchie, "The C Programming Language", PHI Learning, 2nd Edition, 1988.

2. Yashavant Kanetkar, "Exploring C", BPB Publishers, 2nd Edition, 2003.

3. Schildt Herbert, "C: The Complete Reference", Tata McGraw Hill Education, 4th Edition, 2014.

4. R. S. Bichkar, "Programming with C", Universities Press, 2 nd Edition, 2012.

5. Dey Pradeep, Manas Ghosh, "Computer Fundamentals and Programming in C", Oxford University Press, 2nd Edition, 2006.

6. Stephen G. Kochan, "Programming in C", Addison-Wesley Professional, 4th Edition, 2014.

WEB REFERENCES:

1. https://www.nptel.ac.in/courses/108106073/
2. https://www.iare.ac.in

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	PSO'S Course Description on Outcome Based Education (OBE): Course Objectives,Course Outcomes (CO), ProgramOutcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
2	Understand components of a computer	CO 1	T2: 1.1-1.2,R4: 1.1-1.3
3	Identify and apply algorithms and flowcharts for problem solving	CO 1	T2: 2.1-2.2,R4: 1.4
4	Understand pseudo code for a given problem	CO 1	T2: 2.1-2.2
5	Understand the basic structure, process of compiling and running a C program	CO 1	T2: 2.1-2.2,
6	Understand keywords, identifiers, constants, strings, special symbols, variables	CO 1	T2: 1.4 -1.5, R4: 2.1 - 2.4
7	Define the data types, and operators to write C Program	CO 1	T2: 2.1-2.2
8	Understand precedence of operators, expression evaluation	CO 1	T2: 2.3-2.6
9	Understand formatted input/output functions, Type Conversion and type casting in C Programming	CO 1	T2:2.3-2.7
10	Identify and apply decision making statements in C programming	CO 2	T2: 3.1-3.5
11	Identify and apply loop control structures in C programming	CO 2	T2: 5.2-5.3
12	Identify and apply unconditional control structures in C programming	CO 2	T2: 6.1-6.6
13	Understand single dimensional array and multi-deimensional array: declaration, initialization, accessing	CO 3	T2: 6.7
14	Operations on arrays: traversal, reverse, insertion	CO 3	T2: 8.1-8.2, R4: 15.1
15	Operations on arrays: deletion, merge, search	CO 3	T2: 8.3, R4: 15.1

16	Arrays of characters, Reading and writing strings, String handling functions	CO 3	T2: 11.1-11.5
17	Operations on strings: array of strings	CO 3	T2: 4.1-4.5
18	Concept of user defined functions, Function declaration	CO 3	T1: 7
19	return statement, Function prototype	CO 3	T2: 6.9
20	Types of functions, Inter function communication	CO 3	T1: 10, T2:10.1-10.2
21	Function calls, Parameter passing mechanisms, Recursion	CO 3	T2: 10.3-10.4, R4:8.3-8.4
22	Passing arrays to functions, passing strings to functions	CO 3	T2:10.5
23	Storage classes	CO 3	T1: 8.9, R4:8.6.3
24	Basics of pointers, Pointer arithmetic	CO 4	T2: 3.1, R4:11.1
25	Pointer to pointers	CO 4	T2: 3.2
26	Array of pointers	CO 4	T2: 3.2
27	Generic pointer, Null pointers	CO 4	T2: 3.3
28	Pointers as function arguments, Functions returning pointers	CO 4	T2: 3.4-3.5
29	Dynamic memory allocation	CO 4	T2: 6.1-6.6
30	Structure definition, initialization, structure members	CO 4	T2: 12.3-12.4, R4:13.4
31	Nested structures	CO 4	T2: 12.3-12.4, R4:13.4
32	Arrays of structures, structures and functions	CO 4	T2: 2.1-2.2, R4:13.2
33	Structures and pointers, self-referential structures	CO 4	T2: 2.1-2.2
34	Union, bit fields, typedef	CO 4	T2: 12.4
35	Enumerations, Preprocessor directives	CO 4	T1: 8.9, T2: 2.3-2.5
36	Concept of a file, text files and binary files, streams	CO 5	T2: 10.4, R4:14.1-14.4
37	Standard I/O, formatted I/O, file I/O operations	CO 5	T2: 10.4, R4:14.1-14.4
38	Error handling	CO 5	R3: 12.1 - 12.3

39	Line I/O, miscellaneous functions	CO 5	R3: 12.1 - 12.3
40	Applications of C	CO 6	R4: 17
PROBLEM SOLVING/ CASE STUDIES			
1	Write a program in C that takes minutes as input, and display the total number of hours and minutes.	CO 1	T2:2.3-2.6
2	Write a program in C that reads a forename, surname and year of birth and display the names and the year one after another sequentially.	CO 1	T2:2.3-2.7
3	Write a C program to find the third angle of a triangle if two angles are given.	CO 2	T2:3.1-3.5
4	Write a program in C to display the such a pattern for n number of rows using a number which will start with the number 1 and the first and a last number of each row will be 1.	CO 2	T2:5.2-5.3
5	Write a program in C to find the prime numbers within a range of numbers.	CO 2	T2:5.2-5.3
6	Write a program in C to display the n terms of harmonic series and their sum.	CO 2	T2:6.1-6.6
7	Write a program in C to display the pattern like right angle triangle using an asterisk.	CO 2	T2:5.2-5.3
8	Program to accept N integer number and store them in an array AR. The odd elements in the AR are copied into OAR and other elements are copied into EAR. Display the contents of OAR and EAR	CO 3	T2: 6.7
9	Write a C program to illustrate how user authentication is made before allowing the user to access the secured resources. It asks for the user name and then the password. The password that you enter will not be displayed, instead that character is replaced by '*'	CO 3	T2: 8.3, R4:15.1
10	Write a C program to accept a matric and determine whether it is a sparse matrix. A sparse martix is matrix which has more zero elements than nonzero elements	CO 3	T2: 8.1-8.2, R4: 15.1
11	Write a C program to accept a amtric of order MxN and sort all rows of the matrix in ascending order and all columns in descendng order	CO 3	T2: 6.7
12	Write a C program to accept a set of names and sort them in an alphabetical order, Use structures to store the names	CO 4	T2:12.3-12.4, R4:13.4
13	Write a C program to find the sum of two one-dimensional arrays using Dynamic Memory Allocation	CO 4	T2:6.1-6.6
14	Write a program in C to find the content of the file and number of lines in a Text File.	CO 5	T2:10.4, R4:14.1-14.4
15	Write a program in C to replace a specific line with another text in a file.	CO 5	T2:10.4, R4:14.1-14.4
DISCUSSION OF DEFINITION AND TERMINOLOGY			

1	Module I- Components of computers, C programming language	CO 1	T2:1.1-2.6, R4:1.1-2.4
2	Module II- Control structures	CO 2	T2:3.1-6.6
3	Module III- Arrays, Strings and Functions	CO 3	T1:7, T2:6.7-11.5
4	Module IV- Pointers and Structures	CO 4	T2:3.1-6.6, R4:11.1-13.4
5	Module V- File handling functions	CO 5	T2:10.4, R4:14.1-14.4, R3:12.1-12.3
DISCUSSION OF QUESTION BANK			
1	Module I- Components of computers, C programming language	CO 1	T2:1.1-2.6, R4:1.1-2.4
2	Module II- Control structures	CO 2	T2:3.1-6.6
3	Module III- Arrays, Strings and Functions	CO 3	T1:7, T2:6.7-11.5
4	Module IV- Pointers and Structures	CO 4	T2:3.1-6.6, R4:11.1-13.4
5	Module V- File handling functions	CO 5	T2:10.4, R4:14.1-14.4, R3:12.1-12.3

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

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**MATHEMATICAL TRANSFORM TECHNIQUES**				
Course Code	AHSB11				
Program	B.Tech				
Semester	II				
Course Type	Foundation				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Dr. S Jagadha, Associate Professor				

I COURSE PRE-REQUISITES:

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

II COURSE OVERVIEW:

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

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
MATHEMATICAL TRANSFORM TECHNIQUES	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage

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

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

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	Enrich the knowledge of solving algebraic, transcendental and differential equation by numericalmethods
II	The operation of non-periodic functions by Fourier transforms.

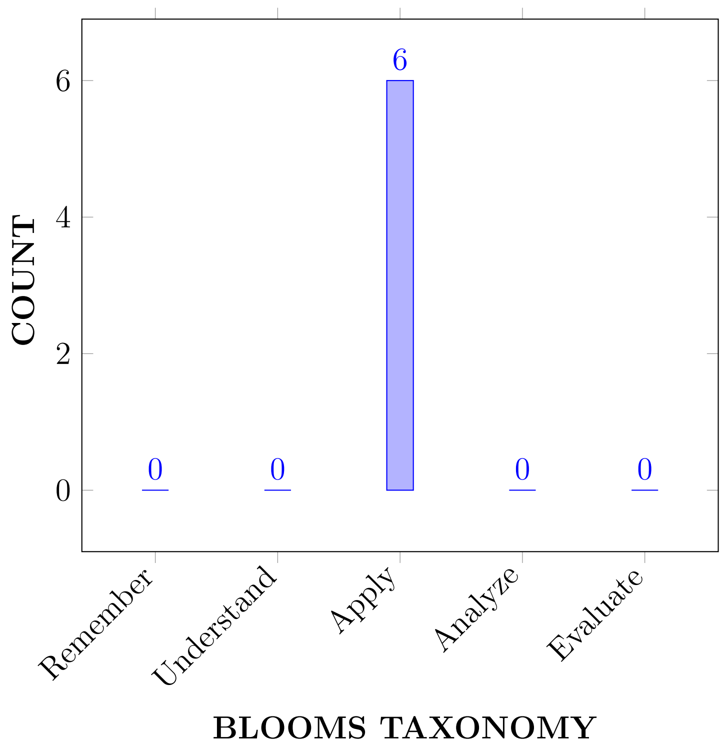
III	The transformation of ordinary differential equations in Laplace field and its applications
IV	The partial differential equation for solving non-linear equations

VII COURSE OUTCOMES:

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

CO 1	**Solve** algebraic and transcendental equations using Bisection method, Regula-falsi method and Newton-Raphson method	Apply
CO 2	**Apply** numerical methods in interpolating the equal and unequal space data	Apply
CO 3	**Make use of** method of least squares to fit poliynomial curves and differential equation by numerical methods	Apply
CO 4	**Apply** the Fourier transform as a mathematical function that transforms a signal from the time domain to the frequency domain, non-periodic function up to infinity	Apply
CO 5	**Explain** the properties of Laplace and inverse transform to various functions the integral transforms operations of calculus to algebra in linear differential equations	Apply
CO 6	**Solve** the linear, nonlinear partial differential equation by the method of Lagrange's ,separiable and Charpit to concern engineering field	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Build the prototype of UAVs and aero-foil models for testing by using low speed wind tunnel towards research in the area of experimental aerodynamics.	2	Seminar/ Conferences/ Research Papers
PSO 2	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	-	-
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	-	-

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Solve complex engineering problems** involving algebraic and transcendental equations using Bisection method, Regula-falsi method and Newton-Raphson method along with **principles of mathematics**.	2
CO 2	PO 1	Apply numerical methods in interpolating the data and fitting the suitable curve in solving complex engineering problems with the help of basic Principle of mathematics to reach valid conclusions.	2
CO3	PO 1	Use numerical methods Taylor's series, Euler's, Picard's and Runge-Kutta methods in solving differential equations encountered in complex engineering problems with the help of basic Principle of mathematics	2
	PO 2	Make use of method of least squares and numerical methods to Identify the statement of the complex engineering problems involving the role of fitting the straight lines, second degree, exponential, power curves,differential equations along with principle of mathematics and interpret the results..	4
	PO4	Make use of the method of least squares in fitting the straight lines ,second degree, exponential, power curves in which coefficients are quantitatively measured by using MATLAB computer software.	1
	PSO1	Make use of the method of least squares in fitting the straight lines ,second degree, exponential, power curves in the design and implementation of complex systems triggered in Aeronautical Engineering	1
CO4	PO 2	Identify the range of non-periodic functions up to infinity and properties of complex Fourier transform in the statement of complex engineering problems which intensifies (apply) the boundary value problems using principle of mathematics related to engineering by the interpretation of results by Fourier integral and Fourier transform	2
	PSO1	Identify the properties of complex Fourier transform concern Aeronautical Engineering which intensifies (apply) the boundary value problems in the design and implementation of complex systems	1
CO5	PO1	Interpret the properties of Laplace and inverse Laplace transform (apply)in solving complex engineering problems for a function of a real variable 't' (time) (apply) to a function of a complex variable 's' (complex frequency) of various functions such as continuous, piecewise continuous, step and impulsive functions with basic Principle of mathematics to reach valid conclusions of engineering problems	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO2	Describe the formulation of integral transforms (knowledge) which converts complex engineering problems using (apply) operations of calculus to algebra along with basic principles of mathematics reaching substantiated conclusions by the interpretation of results in solving linear differential equations	4
CO6	PO1	Apply the method of Lagrange's linear equation Variable separaible to complex engineering problems such as Heat and Wave equations in the domain of engineering (Principle of mathematics and engineering)	2
	PO2	Identify the statement ofproperties of complex Fourier transform (understand)incomplex engineering problemswhich intensifies (apply) the boundary value problems using principle of mathematics related to engineering by the interpretation of results.	4

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 <C≤ 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% ≤ C < 100% – Substantial /High

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	PO1,PO2,PO4	SEE Exams	PO1, PO2, PO4	Seminars	PO1,PO2, PO4
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	PO1,PO2,PO4	5 Minutes Video	PO1,PO2, PO 4	Open Ended Experiments	-
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**ROOT FINDING TECHNIQUES AND INTERPOLATION**
	Solving algebraic and transcendental equations by bisection method, method of false position Newton-Raphson method; Interpolation: Finite differences, forward differences, backward differences and central differences; Symbolic relations; Newton's forward interpolation, Newton's backward interpolation; Gauss forward central difference formula, Gauss backward central difference formula; Interpolation of unequal intervals: Lagrange's interpolation, Newton's divided difference interpolation
MODULE II	**CURVE FITTING AND NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS:**
	Fitting a straight line; Second degree curves; Exponential curve, power curve by method of least squares. Taylor's series method; Step by step methods: Euler's, modified Euler's and Runge-Kutta method

MODULE III	**FOURIER TRANSFORMS**
	Fourier integral theorem, Fourier sine and cosine integrals; Fourier transforms; Fourier sine and cosine transform, properties, inverse transforms, finite Fourier transforms Triple Integrals: Evaluation of triple integrals in Cartesian coordinates; volume of a region using triple integration.
MODULE IV	**LAPLACE TRANSFORMS**
	Definition of Laplace transform, linearity property, piecewise continuous function, existence of Laplace transform, function of exponential order, first and second shifting theorems, change of scale property, Laplace transforms of derivatives and integrals, multiplied by t, divided by t, Laplace transform of periodic functions. Inverse Laplace transform: Definition of Inverse Laplace transform, linearity property, first and second shifting theorems, change of scale property, multiplied by s, divided by s; Convolution theorem and applications to ordinary differential equations.
MODULE V	**PARTIAL DIFFERENTIAL EQUATIONS**
	Formation of partial differential equations by elimination of arbitrary constants and arbitrary functions, solutions of first order linear equations; Charpit's method; Applications of partial differential equations of wave and heat equations

TEXTBOOKS

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

REFERENCE BOOKS:

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

WEB REFERENCES:

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

COURSE WEB PAGE:

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Introduction to outcome based education		
CONTENT DELIVERY (THEORY)			
2	Define Algebraic and Transcendental equations	CO 1	T1:12.1, R1:4.2
3	Apply Bisection method to find the root	CO 1	T1:12.3, R1:4.4
4	Apply False Position method to find the root	CO 1	T1:12.3, R1:4.6
5	Apply Newton-Raphson method to find roots	CO 1	T1:12.3, R1:4.7
6	Define what interpolation is	CO2	T1:12.4, R1:4.13
7	Explain the relation between symbols	CO2	T1:12.4, R1:4.15
8	Solve the problems by Newton's forward method	CO2	T1:12.4, R1:4.20
9	Solve the problems by Newton's backward method	CO 2	T1:12.5, R1:8.8
10	Solve the problems by Gauss forward method	CO 2	T1:13.1, R1:5.3
11	Solve the problems by Gauss backward method	CO 2	T1:13.2, R1:5.5
12	Solve the problems by lagrange's and Newtons dividend difference	CO 2	T1:13.3, R1:5.9
13	Solve a straight line	CO 3	T1:14.4, R1:6.2
14	Solve a second degree parabola	CO 3	T1:15.2 , R1:6.6
15	Solve an exponential curve	CO 3	T1:15.1, R1:7.4,
16	Solve the ODE by Taylor's series method	CO 3	T1:15.1, R1:6.5
17	Solve the ODE by Euler's Method- Euler's modified method	CO 3	T1:15.3, R1:7.9
18	Solve the ODE by Runge-Kutta Methods	CO 3	T2: 7.15, R1:1.65
19	Fourier transform	CO4	T1:22.3 R1:10.8
20	Fourier sine transform	CO4	T1:22.4 R1:10.9
21	Fourier Cosine Transforms	CO4	T1:22.5 R1:10.9

22	Properties of Fourier Transforms	CO4	T1:22.4 R1:10.9
23	Inverse Fourier Transform	CO4	T2:15.5 R1:7.5
24	Finite Fourier Transform	CO4	T2:16.5 R1:7.6
25	Infinite Fourier Transform	CO4	T2:16.5 R1:7.6
26	Aplications of Fourier Transform	CO4	T2:16.5 R1:7.6
27	First, second shifting theorems and change of scale property of Laplace transforms	CO5	T1:21.2 R1:5.1
28	Laplace transforms of Derivatives, Integrals, multiplication and Division by t to a function	CO5	T1:21.4 R1:5.1
29	Laplace transform of periodic functions	CO5	T1:21.7-21.10 R1:5.2-5.4
30	First, second shifting theorems and change of scale property of Inverse Laplace Transforms	CO5	T1:21.12 R1:5.1,5.6
31	Inverse Laplace transforms of Derivatives, Integrals, multiplication and Division by s to a function	CO5	T1:21.13 R1:5.1,5.3
32	Convolution theorem	CO5	T1:21.13 R1:5.4
33	Application of Laplace Transforms	CO5	T1:21.14 R1:5.5
34	Elimination of arbitrary constants(Formation of PDE)	CO6	T1:17.1-17.2 R1:16.1-16.2
35	Elimination of arbitrary functions(Formation of PDE)	CO6	T1:17.5-17.6 R1:16.3.1
36	Non-Linear Partial differential equation of first order	CO6	T1:17.1-17.2 R1:16.1-16.2
37	Standard forms I, II ,III and IV	CO6	T1:17.1-17.2 R1:16.1-16.2
38	Non-Linear Partial differential equation of first order Standard forms V	CO6	T1:17.5-17.6 R1:16.3.1
39	Non-Linear Partial differential equation of first order Standard forms VI	CO6	T1:17.1-17.2 R1:16.1-16.2

40	Lagrange's Linear equation- Method of grouping	CO11	T1:17.5-17.6 R1:16.3.1
41	Lagrange's Linear Equation -Method of Multipliers	CO12	T1:17.1-17.2 R1:16.1-16.2
PROBLEM SOLVING/ CASE STUDIES			
42	Solving problems by Bisection method to find the root	CO 1	T1:12.3, R1:4.4
43	Solving problems on False Position method to find the root	CO 1	T1:12.3, R1:4.6
44	Solving problems on Newton-Raphson method to find roots	CO 1	T1:12.3, R1:4.7
45	Solve the problems by Newton's forward method	CO2	T1:12.4, R1:4.20
46	Solve the problems by Newton's backward method	CO 2	T1:12.5, R1:8.8
47	Solve the problems by Gauss forward method	CO 2	T1:13.1, R1:5.3
48	Solve the problems by Gauss backward method	CO 2	T1:13.2, R1:5.5
49	Solve the problems by lagrange's and Newtons dividend difference	CO 2	T1:13.3, R1:5.9
50	Solve the ODE by Euler's Method- Euler's modified method	CO 3	T1:15.3, R1:7.9
51	Solve the ODE by Runge-Kutta Methods	CO 3	T2: 7.15, R1:1.65
52	Solving problems on Laplace Transform of First, second shifting theorems and change of scale property	CO 4	T1:21.1,21.4 R1:5.1
53	Solving problems on Inverse Laplace transforms of derivatives, integrals, multiplied by s, divided by s	CO 4	T1:21.13 R1:5.1,5.3
54	Solving problems on Convolution theorem	CO 4	T1:21.14 R1:5.5
55	Solving problems on formation of partial differential equations by elimination of arbitrary constants	CO 6	T1:17.1-17.2 R1:16.1-16.2
56	Solving problems on formation of partial differential equations by elimination of arbitrary functions	CO 6	T1:17.1-17.2 R1:16.1-16.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Definitions and terminology on Roots finding techniques and interpolation	CO 1,2	T1:21.1,21.4 R1:5.1
58	Definitions and terminology on Curve fitting and Numerical solution of ordinary differential equations	CO 3	T1:22.1-22.2R1:10.8

59	Definitions and terminology on Fourier transforms	CO 4	T1:22.1-22.2R1:10.8
60	Definitions and terminology on Laplace transforms	CO 5	T1:21.1,21.4 R1:5.1
61	Definitions and terminology on partial differential equations.	CO 6	T1:17.1-17.2 R1:16.1-16.2
DISCUSSION OF QUESTION BANK			
62	Discussion of Roots finding techniques and interpolation	CO 1,2	T1:21.1,21.4 R1:5.1
63	Discussion ofCurve fitting and Numerical solution of ordinary differential equations	CO 3	T1:22.1-22.2 R1:10.8
64	Discussion of Fourier transforms	CO 4	T2:15.5 R1:7.5
65	Discussion of Laplace transforms	CO 5	T2:10.3 R1:16.4
66	Discussion of partial differential equations	CO 6	T1:17.1-17.2 R1:16.1-16.2

Signature of Course Coordinator **HOD,AE**

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

COURSE DESCRIPTION

Department	COMPUER SCIENCE AND ENGINEERING				
Course Title	PROBABILITY AND STATISTICS				
Course Code	AHSB12				
Program	B.Tech				
Semester	II	CSE			
Course Type	Foundation				
Regulation	R- 18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Ms. P. Srilatha, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
10+2	-	-	Fundamentals of Statistics

II COURSE OVERVIEW:

Probability theory is the branch of mathematics that deals with modelling uncertainty. Inferential Statistics and regression analysis together with random variate distributions are playing an exceptional role in designing data driven technology which is familiarly known as data centric engineering. They also have wide variety applications in telecommunications and other engineering disciplines. The course covers advanced topics of probability and statistics with applications over real-world engineering problems.

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

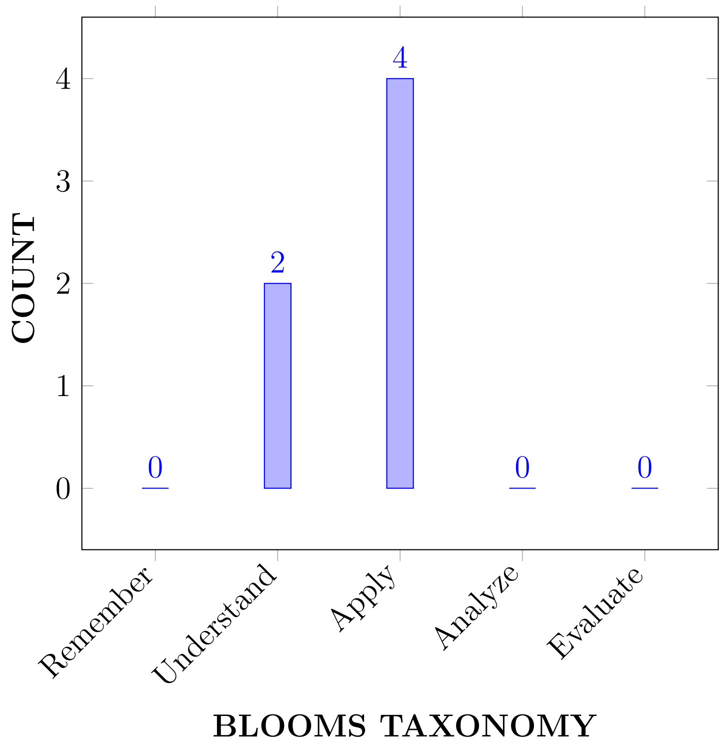
I	The Principles of probability, the theory of random variables, basic random variate distributions and their applications.
II	The Methods and techniques for quantifying the degree of closeness among two or more variables and linear regression analysis.
III	The Estimation statistics and Hypothesis testing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

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	**PO 1**	Explain (understanding) the concept of random variables and their role in solving complex engineering problems involving random events and uncertainty by using Mathematical functions (principles of mathematics).	2
	PO 4	The expected values, variances for the given discrete random variables will be quantitatively measured by using statistical computer software (R-software).	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	**PO 1**	Interpret the Probability distributions such as Binomial, Poisson and Normal distribution (Understanding) with the support of evaluation of integrals (principles of mathematics) and appreciate their importance and applicability (Apply) in solving complex engineering problems involving uncertainty.	2
	PO 2	Understand the statement and formulation of a complex engineering problem which involves the events of uncertainty, Model it with suitable probability distribution and Apply the concepts of discrete or continuous distributions along with basic principles of mathematics to develop the solution and reaching substantiated conclusions by the interpretation of results	5
CO 3	**PO 1**	Interpret (Understand) the results of Bivariate and Correlation Analysis by using ratios, square roots, straight lines and planes (principles of mathematics) for statistical forecasting (Apply)in complex engineering problems involving bivariate or multivariate data.	2
CO 4	**PO 1**	Select appropriate statistical methods (understand) for solving some real-time complex engineering problems governed by correlation with the knowledge of fundamental principles of mathematics.	2
	PO 4	Interpret the results of Bivariate and Multivariate Regression and quantifying the degree of closeness between two or more variables by using statistical computer software (R-software, SPSS-software).	1
CO 5	**PO 1**	Apply tests of hypotheses which involves the role of mathematical tools like statements, sets, ratios and percentages (principles of mathematics) for both large samples and small samples (knowledge) in making decisions over statistical claims that arise in complex engineering problems which requires sampling inspections.	2
	PO 2	Understand the statement and formulation of a complex engineering problem which needs verification of truth values of numerical or statistical hypothesis, collect the necessary information and data through sampling techniques, apply tests of hypotheses (both large and small samples) along with basic principles of mathematics to develop the solution and reaching substantiated conclusions by the interpretation of results	5
	PO 4	Make Use of R software package in computing confidence intervals, statistical averages and hypothesis testing. (Computer software relevance)	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	**PO 1**	Identify the role of types of statistical hypotheses, types of errors, sampling distributions of means and confidence intervals with the aid of statements and sets, percentages (principles of mathematics) in hypothesis testing of complex engineering problems which requires sampling inspections.	2
	PO 4	Test for the assessment of goodness of fit of the given probability distribution model by using statistical quantitative methods and statistical computer software (R-software).	1

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	-	-	9.0	-	-	-	-	-	-	-		-	-	-
CO 2	66.7	50.0	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.7	-	-	9.0	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.7	50.0	-	9.0	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.7	-	-	9.0	-	-	-	-	-	-	-		-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\ \% < C < 60\%$ –Moderate

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

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

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

TEXTBOOKS

1. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley and Sons Publishers, 9th Edition, 2014.
2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 43rd Edition, 2012.

REFERENCE BOOKS:

1. N. P. Bali, "Engineering Mathematics", Laxmi Publications, 9th Edition, 2016.& Co., 6th Edition, 2014.
2. S. C. Gupta, V. K. Kapoor, "Fundamentals of Mathematical Statistics", S. Chand & Co., 10th Edition, 2000.
3. Richard Arnold Johnson, Irwin Miller and John E. Freund, "Probability and Statistics for Engineers", Prentice Hall, 8th Edition, 2013.

WEB REFERENCES:

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

XIX COURSE PLAN:

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

S.No	Topics to be covered	Course outcomes	Reference
OBE DISCUSSION			
1	Identify the types of sampling (random, stratified, systematic, cluster). Identify the misuses of statistics. Student will use appropriate statistical methods to collect, organize, display, and analyze relevant data. Probability & Statistics introduces students to the basic concepts and logic of statistical reasoning and gives the students introductory-level practical ability to choose, generate, and properly interpret appropriate descriptive and inferential methods. Identify the types of data (qualitative, quantitative, discrete, and continuous).		
CONTENT DELIVERY (THEORY)			
2	Introduction on probability	CO 1	T2:26.3
3	conditional probability	CO 1	R2:21.48
4	Baye's law	CO 1	T2:26.6 R2:21.50
5	Discrete Random variables	CO 1	T2:26.7 R2:21.51
6	Mean and variance, probability distribution of discrete Random variables.	CO 1	T2:26.8
7	Continuous Random variables	CO 1	T2:26.10
8	Mean and variance, probability distribution of continuous Random variables.	CO 1	T2:26.14 R2:21.55
9	Properties of random variables	CO 1	T2:26.15 R2:21.58
10	Binomial distribution	CO 2	T2:26.16 R2:21.61
11	Mean and variances of Binomial distribution	CO 2	T2:25.12 R2:21.24
12	Recurrence formula for the Binomial distribution	CO 2	T2:25.16 R2:21.29
13	Poisson distribution	CO 2	T2:25.14 R2:21.31
14	Mean and variance of Poisson distribution	CO 2	T2:25.14 R2:21.33
15	Recurrence formula for the Poisson	CO 2	R2:21.33
16	Normal distribution.	CO 2	T2:27.2 R2:21.64
17	Mean, Variance, Mode, Median, Characteristics of normal distribution	CO 2	T2:27.2

18	Correlation	CO 3	T2:27.2 R2:21.67
19	Karl Pearson's Coefficient of correlation	CO 3	T2:27.2
20	Rank correlation	CO 3	T2:27.3 R2:21.71
21	Properties of correlation	CO 3	T2:27.4 R2:21.68
22	Regression coefficients	CO 4	T2:27.7 R2:21.74
23	Properties of Regression coefficients	CO 4	T2:27.12 R2:21.75
24	Angle between two lines of regression	CO 4	T2:27.8 R2:21.72
25	Lines of regression,	CO 4	T2:27.8 R2:21.73
26	Sampling: Definitions	CO 5	T2:27.14 R2:21.78
27	Types of sampling	CO 5	T2:27.19 R2:21.814
28	Parameter vs. statistics, standard error.	CO 5	T2:27.12 R2:21.82
29	Type I and type II errors, critical region, confidence interval, level of significance. One sided test, two-sided test.	CO 5	T2:27.18 R2:21.82
30	Tests of significance of single mean	CO 5	T2:26.15 R2:21.58
31	Test of difference between means	CO 5	T2:26.16 R2:21.61
32	Tests of significance of single proportion	CO 5	T2:25.14 R2:21.33
33	Test of difference between proportions	CO 5	R2:21.33
34	Small sample tests: Test of equality of two population variances.	CO 6	T2:27.2 R2:21.64
35	Student t-distribution, its properties	CO 6	T2:27.2
36	Test of significance difference between sample mean and population mean.	CO 6	T2:26.16 R2:21.61
37	difference between means of two small samples	CO 6	T2:25.12 R2:21.24
38	Snedecor's F-distribution properties.	CO 6	T2:25.16 R2:21.29
39	F-distribution properties	CO 6	T2:27.14 R2:21.78
40	Chi-square distribution and it's properties	CO 6	T2:27.19 R2:21.814
41	Applications of Chi-square –Distribution	CO 6	T2:27.12 R2:21.82

PROBLEM SOLVING/ CASE STUDIES			
42	Problem solving session on discrete random variable	CO 1	T2:26.3
43	Problem solving session on continuous random variables	CO 1	R2:21.48
44	Problem solving session on mathematical expectation	CO 1	T2:26.6 R2:21.50
45	Problem solving session on Binomial distribution	CO 1	T2:26.7 R2:21.51
46	Problem solving session on Poisson distribution	CO 2	T2:26.8
47	Problem solving session on Normal distribution	CO 2	T2:26.10
48	Problem solving session on Karl Pearson's correlation	CO 3	T2:26.14 R2:21.55
49	Problem solving session on Spearman's rank correlation	CO 3	T2:26.15 R2:21.58
50	Problem solving session on linear regression	CO 4	T2:26.16 R2:21.61
51	Problem solving session on sampling distribution of means	CO 5	T2:25.12 R2:21.24
52	Problem solving session on central limit theorem	CO 5	T2:25.16 R2:21.29
53	Problem solving session on large sample tests	CO 5	T2:25.14 R2:21.31
54	Problem solving session on t-test	CO 6	T2:25.14 R2:21.33
55	Problem solving session on F-test	CO 6	R2:21.33
56	Problem solving session on Chi-square - test	CO 6	T2:27.2 R2:21.64
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Definitions & terminology discussion on probability and random variables	CO 1	T2:26.6 R2:21.50
58	Definitions & terminology discussion on probability distributions.	CO 2	T2:26.7 R2:21.51
59	Definitions & terminology discussion on correlation and regression.	CO 3, CO 4	T2:25.14 R2:21.33
60	Definitions & terminology discussion on Tests of Hypothesis.	CO 5	R2:21.33
61	Definitions & terminology discussion on Tests of significance.	CO 6	R2:21.33

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

Course Coordinator: **HOD CSE**
Ms. P. Srilatha

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**MECHANICS OF SOLIDS LABORATORY**				
Course Code	AAEB06				
Program	B.Tech				
Semester	III	AE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Ms. Ch Ragha Leena, Assistant Professor				

I COURSE OVERVIEW:

The Aeronautical Engineers are required to design aircraft structures like wings, fuselage etc. The loads coming onto these structures, along with the self-weight, have to be safely transmitted. A structural engineer must be able to design a structure in such a way that none of its members fail during load transfer process. This foundational laboratory course in aeronautical is to comprehend and study the mechanical behavior of aerospace materials such as tensile strength, rigidity modulus, hardness, impact strength and compressive strength through a set of experimentations. The students shall verify the experimental results through analytical calculations.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
B.Tech	AMEB03	II	Engineering Mechanics	4

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Strength of materials laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	The mechanical properties of solid engineering materials used in aerospace applications.
II	The behavior of various material under different loads and equilibrium conditions.

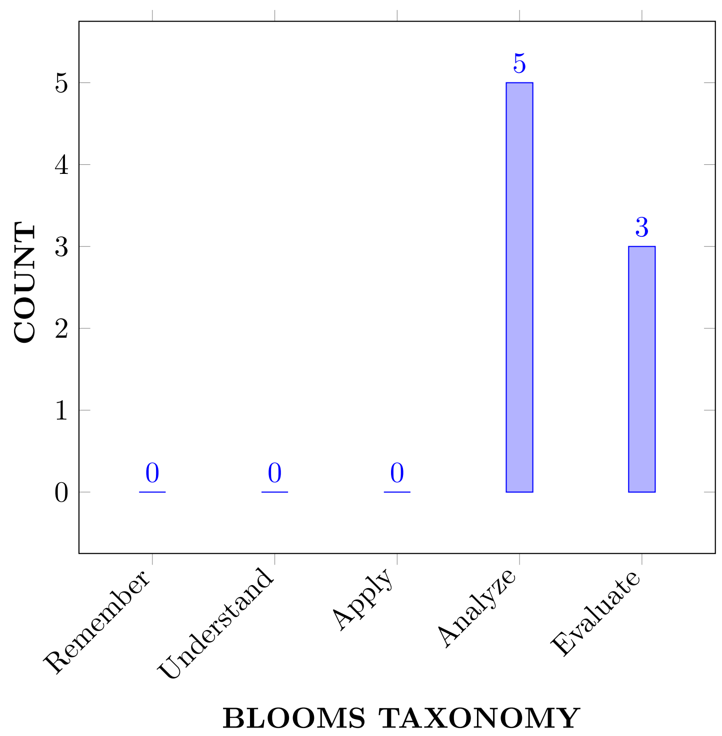
III	The characterization of materials subjected to tension, compression, shear, torsion, bending and impact.
IV	The analyzation of material testing data for selection of aircraft materials

VII COURSE OUTCOMES:

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

CO 1	**Determine** the Hardness of mild steel, carbon steel, brass and aluminum specimens using Brinell's and Rockwell's hardness test for characterization of materials. .	Evaluate
CO 2	**Analyze** young's modulus of a mild steel bar for the calculation of tension using Universal testing machine.	Analyze
CO 3	**Determine** the modulus of rigidity of a given shaft for calculating the angle of twist under torsional loading.	Evaluate
CO 4	**Analyze** the impact strength of steel specimen using Izod and Charpy test for the characterization under suddenly applied load acting on a specimen.	Analyze
CO 5	**Determine** the buckling load and crushing load of long and short columns for designing structures.	Analyze
CO 6	**Analyze** stiffness and modulus of rigidity of the spring wire for designing shock absorbers in aerospace and automobile industries.	Evaluate
CO 7	**Analyze** the young's modulus of material of simply supported beam for calculating bending stresses.	Analyze
CO 8	**Analyze** the beams under point loads for computing shear force, bending moment, slope and deflection in designing structures.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Videos
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	1	Lab Exercise
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1	Videos

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 2	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	1	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Recall the different components in the engineering structures (aircraft materials and bridges) for finding the hardness number by **using mathematics and engineering fundamentals.**	2
	PO 5	Design of trusses by the Use of modern engineering and IT tools including prediction and modeling to complex engineering activities with an **understanding of the limitations.**	1
CO 2	PO 1	Recall (knowledge) the different beam generally come across in design, and calculate tension by applying the principles of **mathematics and engineering fundamentals.**	2

	PO 2	Understand the given **problem statement of** structural members related to young's modulus from the provided **information and data** in reaching substantiated solutions by the **interpretation of results.**	3
	PO 5	Make use of **modern engineering tools** for calculation of tension in members.	1
	PSO 1	Select the appropriate method for the analysis of structures using (**mathematical principles and engineering knowledge**) knowledge for different loads for the design purpose.	2
CO 3	PO 1	Recall (knowledge) different shaft generally come across in design, and calculate angle of twist under torsional load by applying the principles of (**mathematics and engineering fundamentals.**)	2
	PO 2	Analyze the shaft to Calculate angle of twist under torsional loading for determining the rigidity using the structural analysis concepts,**formulate and state a problem, and develop solution and document the results.**	4
	PSO 1	Understand the design of shafts based on Indian standards using **mathematical principles; engineering knowledge** and **document the results** to **support** their applications in **next-level courses** of the program (**own engineering discipline**).	4
CO 4	PO 1	Understand the different components in the engineering structures (structures and bridges) and its behavior by **using mathematics and engineering fundamentals.**	2
	PO 2	Analyze steel specimen for the concept of sudden load acting on a specimen using Izod and Charpy test by **formulate and state a problem, and develop solution and document the results.**	4
	PO 5	Use of **Modern tools** in the design of steel by the concept of sudden loading in steel specimen.	3
CO 5	PO 1	Recall the different components in the engineering structures (multistoried structures and bridges) to determine the buckling and crushing load of columns by **using mathematics and engineering fundamentals.**	2
	PO 5	Design of columns by the Use of modern engineering and IT tools including prediction and modeling to complex engineering activities with an **understanding of the limitations**	1
CO 6	PO 1	Make use of advanced methods of analysis for solving engineering problems related to structures by applying the principles of **engineering fundamentals** and their **integration and support with other engineering disciplines, mathematics.**	2

	PO 2	Analyze the spring wire for critical load combinations to know the design forces using the structural analysis concepts **formulate and state a problem, and develop solution and document the results.**	4
CO 7	PO 1	Recall (knowledge) the different beam deflections generally come across in design, and calculate tension by applying the **principles of mathematics and engineering fundamentals.**	2
	PO 2	Understand the given **problem statement** of structural members related to deflection of beams from the provided **information and data** in reaching substantiated solutions by the **interpretation of results.**	3
	PSO 3	Extend the focus to **understand the innovative and dynamic challenges** involves in evaluation of hydraulic machine performance.	1
CO 8	PO 1	Understand the different components in the engineering structures (multistoried structures and bridges) and its behavior by **using mathematics and engineering fundamentals.**	2
	PO 2	Analyze cantilever beam for calculation of stress and strain using strain gauge test by **formulate** and **state a problem,** and **develop solution** and **document the results.**	4
	PO 5	Use of **Modern tools** in the design of cantilever beam by the concept of stress strain in a specimen.	1

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

COURSE OUTCOMES	PROGRAM OUTCOMES			PSO'S
	PO 1	PO 2	PO 5	PSO 1
CO 1	2		1	1
CO 2	2	1	1	1
CO 3	2	1		
CO 4	2	1	1	1
CO 5	2			
CO 6	2	1		
CO 7	2	1	1	1
CO 8	2	1	1	

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK 1	**BRINELL HARDNESS TEST**
	Determination of Brinell number of a given test specimen.
WEEK 2	**ROCKWELL HARDNESS TEST**
	Determination of hardness number of different specimens such as steel, brass, copper and aluminum.
WEEK 3	**TENSION TEST**
	Study the behaviour of mild steel and various materials under different loads. To determine a) Tensile b) Yield strength c) Elongation d) Young's modulus
WEEK 4	**TORSION TEST**
	Determine of Modulus of rigidity of various specimens.
WEEK 5	**IZOD IMPACT TEST**
	Determination the toughness of the materials like steel, copper, brass and other alloys using Izod test
WEEK 6	**CHARPY IMPACT TEST**
	Determine the toughness of the materials like steel, copper, brass and other alloys using Charpy test.
WEEK 7	**COMPRESSION TEST ON SHORT COLUMN**
	Determine the compressive stress on material.
WEEK 8	**COMPRESSION TEST ON LONG COLUMN**
	Determine Young's modulus of the given long column.
WEEK 9	**TESTING OF SPRINGS**
	Determine the stiffness of the spring and the Modulus of rigidity of wire material.
WEEK 10	**DEFLECTION TEST FOR SSB AND CANTILEVER BEAM**
	Determine the Young's modulus of the given material with the help of deflection of SSB and cantilever beam.
WEEK 11	**REVIEW - I**
	Spare session for additional repetitions and review.
WEEK 12	**REVIEW - II**
	Spare session for additional repetitions and review

TEXTBOOKS

1. Gere, Timoshenko, “Mechanics of Materials”, McGraw Hill, 3rd Edition, 1993.
2. R. S Kurmi, Gupta, “Strength of Materials”, S. Chand, 24th Edition, 2005.
3. William Nash, “Strength of Materials”, Tata McGraw Hill, 4th Edition, 2004.

REFERENCE BOOKS:

1. 1. Mechanics of Materials - Ferdinand P. Beer, E. RusselJhonston Jr., John T. DEwolf – TMH 2002.
2. Strength of Materials by R. Subramanian, Oxford University Press, New Delhi..

XV COURSE PLAN:

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

S.No	Topics to be covered	CO’s	Reference
1	Brinell Hardness Test.	CO 1	T2: 2.6
2	Rockwell Hardness Test.	CO 2	R1: 2.6
3	Tension Test	CO 2	T1: 2.6
4	Torsion Test	CO 3	R1: 2.18 R1:2.18
5	Izod Impact Test	CO 4	T2:2.22
6	Charpy Impact Test	CO 4	T2:2.25
7	Compression Test On Short Column	CO 5	T2:2.26 R1:2.55
8	Compression Test On Long Column	CO 5	T2:2.3
9	Testing Of Springs	CO 6	R1:2.6
10	Deflection Test For Ssb And Cantilever Beam	CO 7, CO 8	T1:2.6

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Demonstration the hardness number of different alloys
2	Demonstrate the behavior of composite materials subjected to different loading conditions.
3	Encourage students to design and analyze of different beams and columns using ANSYS

Signature of Course Coordinator **HOD,AE**
Ms. Ch Ragha Leena, Assistant Professor

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

COURSE DESCRIPTION

Department	**Aeronautical Engineering**				
Course Title	**BASIC ELECTRICAL AND ELECTRONCIS ENGINEERING**				
Course Code	AEEB04				
Program	B.Tech				
Semester	III	AE			
Course Type	Foundation				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Ms.B Navothna, Assistant Professor,EEE				

I COURSE PRE-REQUISITES:

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

II COURSE OVERVIEW:

Basic Electrical and Electronics Engineering course deals with the concepts of electrical circuits, basic law's of electricity, different methods to solve the electrical networks and the instruments to measure the electrical quantities. This course focuses on the construction, operational features of energy conversion devices such as DC and AC machines, Transformers. It also emphasis on basic electronics semiconductor devices and their characteristics and operational features.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Basic Electrical and Electronics Engineering	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
67%	Understand
33%	Apply
0 %	Analyze

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

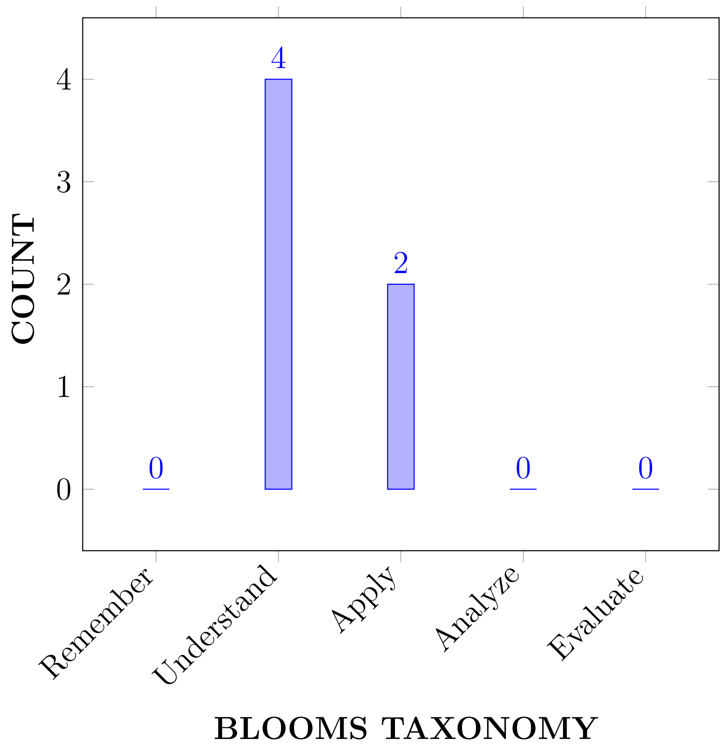
I	Understanding of the basic elements encountered in electric networks, and operation of measuring instruments.
II	The construction and working principle of DC generator, DC motor, andtypes of DC machines based on field excitation method.
III	Analyze the characteristics of alternating quantities and AC machines.
IV	Illustrate the V-I characteristics of various diodes and bi-polar junction transistor.

VII COURSE OUTCOMES:

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

CO 1	**Solve** complex electrical circuits by applying network reduction techniques for reducing into a simplified circuit.	Apply
CO 2	**Differentiate** the working of moving iron and moving coil type instruments for computing electrical qunatities using suitable instrument.	Under-stand
CO 3	**Demonstrate** the construction, principle and working of DC machines for their performance analysis.	Under-stand
CO 4	**Illustrate** alternating quantities of sinusoidal waveform and working , construction of single phase transformers,induction motors, alternators for analysis of AC waveforms and AC machines.	Under-stand
CO 5	**Apply** the PN junction characteristics for the doide applications such as switch and rectifier.	Apply
CO 6	**Extend** the biasing techniques for bipolar and uni-polar transistor amplifier circuits considering stability condition for establishing a proper operating point.	Under-stand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Build the prototype of UAVs and aero-foil models for testing by using low speed wind tunnel towards research in the area of experimental aerodynamics.	1	Quiz

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	**PO 1**	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 mathematical principles and various source transformation techniques are adopted for solving complex circuits.	3
	PO 2	Derive standard expressions for equivalent resistances, inductances and capacitance by using series-parallel networks i.e mathematical calculations.	1
	PSO 1	Solve complex electrical circuits by applying basic circuit concepts by using computer programs.	1
CO 2	**PO 1**	Understand the working principles of indicating instruments and classify types based on construction engineering disciplines.	3
CO 3	**PO 1**	The principle of operation and characteristics of DC machines are explained by applying engineering fundamentals including device physics.	3
CO 4	**PO 1**	Understand about alternating quantities of an AC signal and working of single phase transformers,induction motors and alternators using engineering principles and mathematical equations.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 1	Develop equivalent circuit of single phase transformer referred to both sides by developing computer programs.	1
CO 5	**PO 1**	Outline of materials and brief description of formation of semi-conductor devices by using basic fundamentals of science and engineering.	3
	PO 2	Recognize (knowledge) the working and characteristics of diode and understand application which is rectifier circuit using engineering knowledge, and types of rectifiers.	3
CO 6	**PO 1**	List out various transistor configurations and discuss their working using principles of science and mathematical principles.	3
	PO 2	Explain the concept of biasing and load lines and their applicability in solving problems and working of transistors as switch and amplifier.	3

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

0 - $0 \le C \le 5\%$ – No correlation
1 -$5 < C \le 40\%$ – Low/ Slight
2 - $40\ \% < C < 60\%$ –Moderate
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	1	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 5	3	1	-	-	-	-	-	-	-	-	-		-	-	-
CO 6	3	1	-	-	-	-	-	-	-	-	-		-	-	-
TOTAL	**18**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**
AVERAGE	**3**	**0.5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.3**	**0**	**0**

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**ELECTRICCIRCUITS,ELECTROMAGNETISM AND INSTRUMENTS**
	Electrical Circuits: Basic definitions, types of elements, Ohm's Law, resistive networks, inductive networks, capacitive networks, Kirchhoff's Laws, series, parallel circuits and star delta transformations, simple problems, Faradays law of electromagnetic induction; Instruments: Basic principles of indicating instruments, permanent magnet moving coil and moving iron instruments.
MODULE II	**DC MACHINES**
	DC Machines: Principle of operation of DC generator, EMF equation, principle of operation of DC motors, torque equation, types of DC machines, applications, three point starter.

MODULE III	**ALTERNATING QUANTITIES AND AC MACHINES**
	Alternating Quantities: Sinusoidal AC voltage, average and RMS values, form and peak factor, concept of three phase alternating quantity; Transformer: Principle of operation, EMF equation, losses, efficiency and regulation. Three Phase Induction Motor: Principle of operation, slip, slip torque characteristics, efficiency, applications; Alternator: Principle of operation, EMF Equation, efficiency, regulation by synchronous impedance method.
MODULE IV	**SEMICONDUCTOR DIODE AND APPLICATIONS**
	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 V	**BIPOLAR JUNCTION TRANSISTOR AND APPLICATIONS**
	Bipolar junction: Working principle of transistors, DC characteristics, CE, CB, CC configurations, biasing, load line, applications.

TEXTBOOKS

1. A Chakrabarti, "Circuit Theory", Dhanpat Rai Publications, 6thEdition,2004.

2. K S Suresh Kumar, "Electric Circuit Analysis", Pearson Education, 1stEdition,2013.

3. WillianmHayt, Jack E Kemmerly S M Durbin, "Engineering Circuit Analysis", Tata McGraw Hill, 7thEdition,2010.

4. J P J Millman, C CHalkias, SatyabrataJit, "Millman s Electronic Devices and Circuits", Tata McGraw Hill, 2ndEdition,1998.

5. R L Boylestad, Louis Nashelsky, "Electronic Devices and Circuits", PEI / PHI, 9th Edition, 2006.

6. V K Mehta, Rohit Mehta, Principles of electrical engineering, S CHAND, 1st Edition, 2003.

REFERENCE BOOKS:

1. David A Bell, "Electric Circuits", Oxford University Press, 9thEdition,2016.

2. U A Bakshi,Atul P Godse "Basic Electrical and Electronics Engineering"TechnicalPublications, 9thEdition,2016.

3. A Bruce Carlson, "Circuits", Cengage Learning, 1stEdition,2008.

4. M Arshad, "Network Analysis and Circuits", Infinity Science Press, 9thEdition,2016.

WEB REFERENCES:

1. http://www.igniteengineers.com

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

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

COURSE WEB PAGE:

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

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	-
CONTENT DELIVERY (THEORY)			
2	Electrical Circuits: Basic definitions, Types of elements	CO 1	T1-5.2 to 5.3
3	Ohm's Law, Kirchhoff Laws	CO 1	T1-5.4 to 5.5
4	Series, parallel circuits	CO 1	T1-5.5 to 5.8
5	Derivation for Star-delta and delta-star transformations	CO 1	T1-5.8 to 5.9
6	Mesh analysis and Nodal Analysis	CO 1	T1-5.11 to 5.12
7	Working of moving iron type instruments	CO 2	T1-5.14 to 5.15
8	Working of moving coil type inst0ruments	CO 2	T1-5.16 to 5.16
9	Principle of operation for DC generators	CO 3	R2-7.1 to 7.2
10	Construction and EMF equation for DC generators	CO 3	R2-7.4
11	Types of DC generators	CO 3	R2-7.3
12	Principle of operation for DC motors	CO 3	R2-7.3.1 to 7.3.2
13	Back EMF, torque equation for DC motors	CO 3	R2-7.3.3 to 7.3.6
14	Types of DC motors	CO 3	R2-7.6
15	Losses and efficiency for DC generators, motors	CO 3	T1-13.1 to 13.3
16	Principle of operation for Single Phase Transformers	CO 4	T1-13.1 to 13.3
17	Construction and EMF equation for Single Phase Transformers	CO 4	T1-13.5 to 13.6
18	Types of transformers and turns ratio	CO 4	T1-13.6 to 13.7
19	Operation of transformer under no load	CO 4	T1-13.7 to 13.9
20	Operation of transformer under on load	CO 4	T1-13.8
21	Equivalent circuit for Transformers	CO 4	T1-17.1 to 17.2

21	Phasor diagrams of transformer	CO 4	T1-17.3 to 17.4
22	Losses of Transformers	CO 4	T1-17.6 to 17.7
23	Efficiency of Transformers	CO 4	T1-13.11
24	Regulation for Transformers	CO 4	T1-13.12
25	Three Phase Induction motor: Principle of operation	CO 4	T1-13.13
26	slip, slip -torque characteristics	CO 4	T1-13.14
27	Alternators: Introduction, principle of operation	CO 4	T1-13.19
28	Constructional features	CO 4	T1-13.20
29	Understand the concept of P-N junction diode, symbol	CO 5	T1-13.8
30	Learn the V-I characteristics of P-N junction diode	CO 5	T1-17.1 to 17.2
31	Discuss the concept of half wave rectifier and full wave rectifier	CO 5	T1-17.3 to 17.4
32	Understand the bridge rectifiers and filters	CO 5	T1-17.6 to 17.7
33	Discuss the concept of diode as a switch, Zener diode as a voltage regulator	CO 5	T1-13.11
34	Know the concept of Transistors and Understand the configurations	CO 6	T1-13.12
35	Understand the DC characteristics of transistor	CO 6	T1-13.13
36	Understand the biasing and load line analysis.	CO 6	T1-13.13
37	Discuss how transistor acts as an amplifier.	CO 6	T1-13.13
PROBLEM SOLVING/ CASE STUDIES			
38	Numerical Examples on electrical quantities, Ohm's law, KCL, KVL	CO 1	T1-5.8 to 5.9
39	Numerical Examples on series, parallel elements and star to delta transformation and mesh analysis	CO 1	T1-5.5 to 5.8
40	Numerical Examples on nodal analysis and alternating quantities	CO 1	T1-6.8 to 6.9
41	Numerical Examples on Superposition theorem	CO 1	T1-6.2 to 6.3
42	Numerical Examples on reciprocity and maximum power transfer theorems	CO 1	R2-7.1 to 7.2
43	Numerical Examples on Thevenin's and Norton's theorems	CO 1	T1-13.1 to 13.3
44	Numerical Examples on EMF equation and types of DC generators	CO 3	T1-13.6 to 13.7
45	Numerical Examples on torque equation of DC motor	CO 3	T1-13.1 to 13.3
46	Numerical Examples on types of DC motors	CO 3	T1-13.13
47	Numerical Examples on EMF equation and equivalent circuit of 1 phase transformer	CO 4	T1-13.16 to 13.18
48	Numerical Examples on, efficiency for Transformers	CO 4	T1-13.14
49	Numerical Examples on, regulation for Transformers	CO 4	T1-13.16 to 13.18

50	Numerical Examples on EMF of Alternators	CO 4	T1-13.19
51	Numerical Examples on regulation of Alternators	CO 4	T1-13.20
52	Numerical Examples on Rectifiers	CO 5	T1-13.19
53	Numerical Examples on transistors	CO 6	T1-13.19
DISCUSSION OF DEFINITION AND TERMINOLOGY			
54	Definitions on basics of electrical circuits and electrical instruments	CO 1	T1-5.1 to 5.3
55	Definitions on DC machines	CO 2	T1-6.1 to 6.3
56	Definitions on single phase AC circuits and AC machines	CO 3	R2-7.1 to 7.2
57	Definitions on semiconductor diode and applications	CO 5	T1-13.1 to 13.3
58	Definitions on bipolar junction transistor and applications	CO 6	T1-13.11
DISCUSSION OF QUESTION BANK			
59	Questions from electrical circuits and electrical instruments	CO 1	T1-5.1 to 5.3
60	Questions from DC machines	CO 2	T1-6.1 to 6.3
61	Questions from single phase AC circuits and AC machines	CO 3	R2-7.1 to 7.2
62	Questions from semiconductor diode and applications	CO 5	T1-13.1 to 13.3
63	Questions from bipolar junction transistor and applications	CO 6	T1-13.11

Signature of Course Coordinator **HOD,AE**

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

COMPUTER SCIENCE AND ENGINEERING

TECH TALK TOPICS

Department	**COMPUTER SCIENCE AND ENGINEERING**				
Course Title	**DATA STRUCTURES**				
Course Code	ACSB03				
Program	B.Tech				
Semester	III				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	3	1.5
Course Coordinator	Dr V Sitharamulu, Associate Professor				

COURSE OBJECTIVES:

The students will try to learn:

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

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

TECH TALK TOPICS:

S.No	Title of the Topic	Source	Publisher	CO's
1	Graph Structure Learning from Unlabeled Data for Early Outbreak Detection	IEEE Intelligent Systems (Mar.-Apr. 2017, pp. 80-84, vol. 32)	IEEE	CO3,CO4
2	Algorithms behind modern storage systems	Communications of the ACM (Volume 6 1Issue 8August 2018)	ACM	CO1,CO3,CO4
3	Algorithms Behind Modern Storage Systems: Different uses for read-optimized B-trees and write-optimized LSM-trees	Queue, (Volume16,Issue 2 ,March-April 2018)	ACM	CO1,CO3,CO4
4	Efficient Graph Search	Queue(,Volume 18 Issue 4 July-August 2020 Pages: 10)	ACM	CO3,CO4,CO6
5	In search of a strategy against misinformation	XRDS: Crossroads, The ACM Magazine for Students (Volume 27Issue 1Fall 2020)	ACM	CO1,CO2,CO6
6	Quicksort: Unexpected speed-up in Java on multiprocessors	ACM Inroads,(Volume 1,Issue 2,June 2010)	ACM	CO2,CO4,CO6
7	ITiCSE best paper: the educational insights and opportunities afforded by the nuances of Prim's and Kruskal's MST algorithms	ACM Inroads,(Volume 10Issue 1March 2019)	ACM	CO3,CO4,CO6

8	Lower bounds for external memory integer sorting via network coding	Communications of the ACM,(Volume 63Issue 10October 2020)	ACM	CO2,CO4,CO6
9	Sorting algorithms: when the internet gives you lemons, organize a course festival	ACM Inroads,(Volume 6Issue 1March 2015)	ACM	CO2,CO4,CO6
10	10 Optimizations on Linear Search	Communications of the ACM, (Volume 59Issue 9September 2016)	ACM	CO2,CO6
11	Fast and powerful hashing using tabulation	Communications of the ACM (Volume 60,Issue 7July 2017)	ACM	CO5,
12	Technical Perspective: Building a better hash function	Communications of the ACM, (Volume 60Issue 7July 2017)	ACM	CO5,CO6
13	Creating hash functions using intrinsic functions	XRDS: Crossroads, The ACM Magazine for Students(Volume 27Issue 4Summer 2021)	ACM	CO5,CO6
14	Theory and applications of b-bit minwise hashing	Communications of the ACM (Volume 54 Issue 8 August 2011)	ACM	CO4,CO6
15	GRAPH:Deeply understanding graph-based Sybil detection techniques via empirical analysis on graph processing	China Communications, (Volume: 17, Issue: 10, Oct. 2020)	IEEE	CO3,CO4
16	Key-Node-Separated Graph Clustering and Layouts for Human Relationship Graph Visualization	IEEE Computer Graphics and Applications (Volume: 35, Issue: 6, Nov.-Dec. 2015)	IEEE	CO3,CO4,CO6
17	Community-Aware Graph Signal Processing: Modularity Defines New Ways of Processing Graph Signals	IEEE Signal Processing Magazine (Volume: 37, Issue: 6, Nov. 2020)	IEEE	CO3,CO4,CO6

18	Graphs, Convolutions, and Neural Networks: From Graph Filters to Graph Neural Networks	IEEE Signal Processing Magazine (Volume: 37, Issue: 6, Nov. 2020)	IEEE	CO3,CO4,CO6
19	Graph Structure Learning from Unlabeled Data for Early Outbreak Detection	IEEE Intelligent Systems (Volume: 32, Issue: 2, Mar.-Apr. 2017)	IEEE	CO3,CO4,CO6
20	High Tech, High Sec.: Security Concerns in Graph Databases	IT Professional (Volume: 17, Issue: 1, Jan.-Feb. 2015)	IEEE	CO3,CO4,CO6
21	Improving centralized path calculation based on graph compression	China Communications (Volume: 15, Issue: 6, June 2018)	IEEE	CO3,CO4,CO6
22	Edge coloring of graphs with applications in coding theory	China Communications (Volume: 18, Issue: 1, Jan. 2021)	IEEE	CO3,CO4,CO6
23	Calculate joint probability distribution of steady directed cyclic graph with local data and domain casual knowledge	China Communications (Volume: 15, Issue: 7, July 2018)	IEEE	CO3,CO4,CO6
24	Graph Databases for Knowledge Management	IT Professional (Volume: 19, Issue: 6, November/December 2017)	IEEE	CO3,CO4,CO6
25	High-Performance with an In-GPU Graph Database Cache	IT Professional (Volume: 19, Issue: 6, November/December 2017)	IEEE	CO3,CO4,CO6
26	Transmuting Information to Knowledge with an Enterprise Knowledge Graph	IT Professional (Volume: 19, Issue: 6, November/December 2017)	IEEE	CO3,CO4,CO6
27	Deep Residual Split Directed Graph Convolutional Neural Networks for Action Recognition	IEEE MultiMedia (Volume: 27, Issue: 4, Oct.-Dec. 1 2020)	IEEE	CO3,CO4,CO6

28	A General Methodology on Designing Acyclic Channel Dependency Graphs in Interconnection Networks	IEEE Micro (Volume: 38, Issue: 3, May./Jun. 2018)	IEEE	CO3,CO4,CO6
29	Modeling XACML Security Policies Using Graph Databases	IT Professional (Volume: 19, Issue: 6, November/December 2017)	IEEE	CO3,CO4,CO6
30	Response to "Scale Up or Scale Out for Graph Processing"	IEEE Internet Computing (Volume: 22, Issue: 5, Sep./Oct. 2018)	IEEE	CO3,CO4,CO6
31	Fog computing dynamic load balancing mechanism based on graph repartitioning	China Communications (Volume: 13, Issue: 3, March 2016)	IEEE	CO3,CO4,CO6
32	Low-Dimensional Models for Traffic Data Processing Using Graph Fourier Transform	Computing in Science and Engineering(Volume: 20, Issue: 2, Mar./Apr. 2018)	IEEE	CO3,CO4,CO6
33	Graph Analytics Accelerators for Cognitive Systems	IEEE Micro (Volume: 37, Issue: 1, Jan.-Feb. 2017)	IEEE	CO3,CO4,CO6
34	Random Node-Asynchronous Graph Computations: Novel Opportunities for Discrete-Time State-Space Recursions	IEEE Signal Processing Magazine (Volume: 37, Issue: 6, Nov. 2020)	IEEE	CO3,CO4,CO6
35	Signal Processing on Directed Graphs: The Role of Edge Directionality When Processing and Learning From Network Data	IEEE Signal Processing Magazine (Volume: 37, Issue: 6, Nov. 2020)	IEEE	CO3,CO4,CO6
36	Evaluating the Readability of Force Directed Graph Layouts: A Deep Learning Approach	IEEE Computer Graphics and Applications (Volume: 39, Issue: 4, July-Aug. 1 2019)	IEEE	CO3,CO4,CO6

37	Wavelet-Based Visual Analysis for Data Exploration	Computing in Science and Engineering (Volume: 19, Issue: 5, 2017)	IEEE	CO3,CO4,CO6
38	Efficient Situational Scheduling of Graph Workloads on Single-Chip Multicores and GPUs	IEEE Micro (Volume: 37, Issue: 1, Jan.-Feb. 2017)	IEEE	CO3,CO4,CO6
39	Localized Spectral Graph Filter Frames: A Unifying Framework, Survey of Design Considerations, and Numerical Comparison	IEEE Signal Processing Magazine (Volume: 37, Issue: 6, Nov. 2020)	IEEE	CO3,CO4,CO6
40	A User Guide to Low-Pass Graph Signal Processing and Its Applications: Tools and Applications	IEEE Signal Processing Magazine (Volume: 37, Issue: 6, Nov. 2020)	IEEE	CO3,CO4,CO6
41	Software and Dependencies in Research Citation Graphs	Computing in Science and Engineering (Volume: 22, Issue: 2, March-April 2020)	IEEE	CO3,CO4,CO6
42	Scale Up or Scale Out for Graph Processing?	IEEE Internet Computing (Volume: 22, Issue: 3, May./Jun. 2018)	IEEE	CO3,CO4,CO6
43	Connecting the Dots: Identifying Network Structure via Graph Signal Processing	IEEE Signal Processing Magazine (Volume: 36, Issue: 3, May 2019)	IEEE	CO3,CO4,CO6
44	Learning Graphs From Data: A Signal Representation Perspective	IEEE Signal Processing Magazine (Volume: 36, Issue: 3, May 2019)	IEEE	CO3,CO4,CO6
45	Trees: UP-TreeRec: Building dynamic user profiles tree for news recommendation	China Communications9 Volume: 16, Issue: 4, April 20190	IEEE	CO3,CO4,CO6

46	A shortest-path tree approach for routing in space networks	China Communications (Volume: 17, Issue: 7, July 2020)	IEEE	CO3,CO4,CO6
47	Design and Optimization of a Horizontally Partitioned, High-Speed, 3D Tree-Based FPGA	IEEE Micro(Volume: 35, Issue: 6, Nov.-Dec. 2015)	IEEE	CO3,CO4,CO6
48	Steiner tree based optimal resource caching scheme in fog computing	China Communications (Volume: 12, Issue: 8, August 2015)	IEEE	CO3,CO4,CO6
49	Hash tree based trustworthiness verification mechanism in virtual environment	China Communications(Volume: 13, Issue: 3, March 2016)	IEEE	CO5,CO4,CO6
50	Tree MIS: Caring for Ecological Assets in Smart Cities	IT Professional (Volume: 18, Issue: 4, July-Aug. 2016)	IEEE	CO3,CO4,CO6
51	Tree-Based Attack–Defense Model for Risk Assessment in Multi-UAV Networks	IEEE Consumer Electronics Magazine (Volume: 8, Issue: 6, Nov. 1 2019)	IEEE	CO3,CO4,CO6
52	Refining fault trees using aviation definitions for consequence severity	IEEE Aerospace and Electronic Systems Magazine (Volume: 32, Issue: 3, March 2017)	IEEE	CO3,CO4,CO6
53	BEEP: Balancing Energy, Redundancy, and Performance in Fat-Tree Data Center Networks	IEEE Internet Computing(Volume: 21, Issue: 4, 2017)	IEEE	CO3,CO4,CO6
54	A Deep-Tree-Model-Based Radio Resource Distribution for 5G Networks	IEEE Wireless Communications (Volume: 27, Issue: 1, February 2020)	IEEE	CO3,CO4,CO6
55	Path2SL: Leveraging InfiniBand Resources to Reduce Head-of-Line Blocking in Fat Trees	IEEE Micro (Volume: 40, Issue: 1, Jan.-Feb. 1 2020)	IEEE	CO3,CO4,CO6
56	High-Quality Fault Resiliency in Fat Trees	IEEE Micro (Volume: 40, Issue: 1, Jan.-Feb. 1 2020)	IEEE	CO3,CO4,CO6

57	A survivability routing mechanism in SDN enabled wireless mesh networks: Design and evaluation	China Communications (Volume: 13, Issue: 7, July 2016)	IEEE	CO3,CO4,CO6
58	This AI can see the forest and the trees	IEEE Spectrum (Volume: 57, Issue: 8, Aug. 2020)	IEEE	CO3,CO4,CO6
59	Signaling Through Scattered Vegetation: Empirical Loss Modeling for Low Elevation Angle Satellite Paths Obstructed by Isolated Thin Trees	IEEE Vehicular Technology Magazine (Volume: 11, Issue: 3, Sept. 2016)	IEEE	CO3,CO4,CO6
60	Queue: Design and implementation of an adaptive feedback queue algorithm over OpenFlow networks	China Communications (Volume: 15, Issue: 7, July 2018)	IEEE	CO3,CO4,CO6
61	Decoupled delay and bandwidth centralized queue-based QoS scheme in OpenFlow networks	China Communications (Volume: 16, Issue: 7, July 2019)	IEEE	CO3,CO4,CO6
62	Array and Data Structure: Algorithms and Data Structures for New Models of Computation	IT Professional (Volume: 23, Issue: 1, Jan.-Feb. 1 2021)	IEEE	CO3,CO4,CO6
63	TREE: Secure and Efficient Privacy-Preserving Ciphertext Retrieval in Connected Vehicular Cloud Computing	IEEE Network (Volume: 32, Issue: 3, May/June 2018)	IEEE	CO3,CO4,CO6
64	Interactive Partitioning of 3D Models into Printable Parts	IEEE Computer Graphics and Applications (Volume: 38, Issue: 4, Jul./Aug. 2018)	IEEE	CO3,CO4,CO6
65	Radio-Frequency-Identification-Based Intelligent Packaging: Electromagnetic Classification of Tropical Fruit Ripening	IEEE Antennas and Propagation Magazine (Volume: 62, Issue: 5, Oct. 2020)	IEEE	CO3,CO4,CO6
66	B+ tree:Secure and Efficient Privacy-Preserving Ciphertext Retrieval in Connected Vehicular Cloud Computing	IEEE Network (Volume: 32, Issue: 3, May/June 2018)	IEEE	CO3,CO4,CO6

67	Hashing and collision:New collision paths for round-reduced SKINNY-Hash	China Communications(Volume: 17, Issue: 6, June 2020)	IEEE	CO3,CO4,CO6
68	Hash tree based trustworthiness verification mechanism in virtual environment	China Communications (Volume: 13, Issue: 3, March 2016)	IEEE	CO3,CO4,CO6
69	Multimedia Hashing and Networking	IEEE MultiMedia (Volume: 23, Issue: 3, July-Sept. 2016)	IEEE	CO3,CO4,CO6
70	Multiview Cross-Media Hashing with Semantic Consistency	IEEE MultiMedia (Volume: 25, Issue: 2, Apr.-Jun. 2018)	IEEE	CO3,CO4,CO6
71	Nonlinear Discrete Cross-Modal Hashing for Visual-Textual Data	IEEE MultiMedia (Volume: 24, Issue: 2, Apr.-June 2017)	IEEE	CO3,CO4,CO6
72	Double Hashing Sort Algorithm	Computing in Science and Engineering (Volume: 19, Issue: 2, Mar.-Apr. 2017)	IEEE	CO3,CO4,CO6
73	On-line popularity monitoring method based on bloom filters and hash tables for differentiated traffic	China Communications (Volume: 13, Issue: Supplement 1, 2016)	IEEE	CO3,CO4,CO6
74	Collaborative Generative Hashing for Marketing and Fast Cold-Start Recommendation	IEEE Intelligent Systems (Volume: 35, Issue: 5, Sept.-Oct. 1 2020)	IEEE	CO3,CO4,CO6
75	Flexible Packet Matching with Single Double Cuckoo Hash	IEEE Communications Magazine (Volume: 55, Issue: 6, June 2017)	IEEE	CO3,CO4,CO6
76	Hash Access: Trustworthy Grant-Free IoT Access Enabled by Blockchain Radio Access Networks	IEEE Network (Volume: 34, Issue: 1, January/February 2020)	IEEE	CO4,CO5,CO6
77	Write Deduplication and Hash Mode Encryption for Secure Nonvolatile Main Memory	IEEE Micro (Volume: 39, Issue: 1, Jan.-Feb. 2019)	IEEE	CO4,CO5,CO6

78	Hash-Based Signatures: State of Play	IEEE Security and Privacy (Volume: 15, Issue: 4, 2017)	IEEE	CO4,CO5,CO6
79	Hans Peter Luhn and the birth of the hashing algorithm	IEEE Spectrum (Volume: 55, Issue: 2, February 2018)	IEEE	CO3,CO4,CO6
80	Double Hashing Sort Algorithm	Computing in Science and Engineering(Volume: 19, Issue: 2, Mar.-Apr. 2017)	IEEE	CO5,CO6
81	A Query-Based Framework for Searching, Sorting, and Exploring Data Ensembles	Computing in Science and Engineering (Volume: 22, Issue: 2, March-April 2020)	IEEE	CO3,CO4,CO6
82	Graph:The graph isomorphism problem	Communications of the ACM (Volume 63 Issue 11November 2020)	ACM	CO3,CO4,CO6
83	The future is big graphs: a community view on graph processing systems	Communications of the ACM (Volume 64 Issue 9September 2021)	ACM	CO3,CO4,CO6
84	Technical perspective: A graph-theoretic framework traces task planning	Communications of the ACM (Volume 61Issue 3March 2018)	ACM	CO3,CO4,CO6
85	Technical Perspective: Building a better hash function	Communications of the ACM (Volume 60Issue 7July 2017)	ACM	CO3,CO4,CO6
86	A* search: what's in a name?	Communications of the ACM (Volume 63Issue 1January 2020)	ACM	CO2,CO3
87	Hans Peter Luhn and the birth of the hashing algorithm	IEEE Spectrum (Volume: 55, Issue: 2, February 2018)	IEEE	CO3,CO4,CO6
88	Searching algorithm:Asymmetrical quantum encryption protocol based on quantum search algorithm	China Communications (Volume: 11, Issue: 9, Sept. 2014)	IEEE	CO3,CO4,CO6

89	Projected Residual Vector Quantization for ANN Search	IEEE MultiMedia (Volume: 21, Issue: 3, July-Sept. 2014)	IEEE	CO3,CO4,CO6
90	Integrating Tabu Search in Particle Swarm Optimization for the frequency assignment problem	China Communications (Volume: 13, Issue: 3, March 2016)	IEEE	CO3,CO4,CO6
91	An effective long string searching algorithm towards component security testing	China Communications (Volume: 13, Issue: 11, Nov. 2016)	IEEE	CO3,CO4,CO6
92	Routing protocol based on Grover's searching algorithm for Mobile Ad-hoc Networks	China Communications (Volume: 10, Issue: 3, March 2013)	IEEE	CO3,CO4,CO6
93	Feature Selection in Life Science Classification: Metaheuristic Swarm Search	IT Professional (Volume: 16, Issue: 4, July-Aug. 2014)	IEEE	CO3,CO4,CO6
94	Vocabulary Hierarchy Optimization and Transfer for Scalable Image Search	IEEE MultiMedia (Volume: 18, Issue: 3, March 2011	IEEE	CO3,CO4,CO6
95	Excellence in Search: An Interview with David Chaiken	IEEE Software Volume: 29, Issue: 1, Jan.-Feb. 2012)	IEEE	CO3,CO4,CO6
96	An Adaptive Variable Neighborhood Search for a Heterogeneous Fleet Vehicle Routing Problem with Three-Dimensional Loading Constraints: Fibonacci heap data structure is used	IEEE Computational Intelligence Magazine (Volume: 9, Issue: 4, Nov. 2014)	IEEE	CO3,CO4,CO6
97	Membership proof and verification in authenticated skip lists based on heap	China Communications (Volume: 13, Issue: 6, June 2016)	IEEE	CO3,CO4,CO6
98	A practical online approach to protecting kernel heap buffers in kernel modules	China Communications (Volume: 13, Issue: 11, Nov. 2016)	IEEE	CO3,CO4,CO6
99	Secure and Efficient Privacy-Preserving Ciphertext Retrieval in Connected Vehicular Cloud Computing	IEEE Network (Volume: 32, Issue: 3, May/June 2018)	IEEE	CO3,CO4,CO6

100	Distinct Sector Hashes for Target File Detection	Computer (Volume: 45, Issue: 12, Dec. 2012)	IEEE	CO4,CO5,CO6
101	Hover: Trustworthy Elections with Hash-Only Verification	IEEE Security and Privacy (Volume: 10, Issue: 5, Sept.-Oct. 2012)	IEEE	CO4,CO5,CO6
102	Large Visual Repository Search with Hash Collision Design Optimization	IEEE MultiMedia (Volume: 20, Issue: 2, April-June 2013)	IEEE	CO3,CO4,CO6
103	Evaluating Geospatial Geometry and Proximity Queries Using Distributed Hash Tables	Computing in Science and Engineering (Volume: 16, Issue: 4, July-Aug. 2014)	IEEE	CO3,CO4,CO6
104	Improving playback quality of peer-to-peer live streaming systems by joint scheduling and distributed Hash table based compensation	China Communications (Volume: 10, Issue: 6, June 2013)	IEEE	CO3,CO4,CO6
105	A Mutual Authentication Protocol for RFID	IT Professional (Volume: 13, Issue: 2, March-April 2011)	IEEE	CO3,CO4,CO6
106	Auto-aligned sharing fuzzy fingerprint vault	China Communications (Volume: 10, Issue: 10, Oct. 2013)	IEEE	CO3,CO4,CO6
107	Evaluation: A Challenge for Visual Analytics	Computer (Volume: 46, Issue: 7, July 2013)	IEEE	CO3,CO4,CO6
108	Ideas Ahead of Their Time: Digital Time Stamping	EEE Security and Privacy (Volume: 13, Issue: 4, July-Aug. 2015)	IEEE	CO3,CO4,CO6
109	The Shim6 architecture for IPv6 multihoming	IEEE Communications Magazine (Volume: 48, Issue: 9, Sept. 2010)	IEEE	CO3,CO4,CO6
110	Multilabels-Based Scalable Access Control for Big Data Applications	IEEE Cloud Computing (Volume: 1, Issue: 3, Sept. 2014)	IEEE	CO3,CO4,CO6

111	Graph:User-oriented graph based frequency allocation algorithm for densely deployed femtocell network	China Communications (Volume: 10, Issue: 12, Dec. 2013)	IEEE	CO3,CO4,CO6
112	Spectral Regression with Low-Rank Approximation for Dynamic Graph Link Prediction	IEEE Intelligent Systems (Volume: 26, Issue: 4, July-Aug. 2011)	IEEE	CO3,CO4,CO6
113	Graph-based lexicalized reordering models for statistical machine translation	China Communications (Volume: 11, Issue: 5, May 2014)	IEEE	CO3,CO4,CO6
114	A Semantic Graph of Traffic Scenes for Intelligent Vehicle Systems	IEEE Intelligent Systems (Volume: 27, Issue: 4, July-Aug. 2012)	IEEE	CO3,CO4,CO6
115	Big Data Analysis with Signal Processing on Graphs: Representation and processing of massive data sets with irregular structure	IEEE Signal Processing Magazine (Volume: 31, Issue: 5, Sept. 2014)	IEEE	CO3,CO4,CO6
116	Dependability analysis for fault-tolerant computer systems using dynamic fault graphs	China Communications (Volume: 11, Issue: 9, Sept. 2014)	IEEE	CO3,CO4,CO6
117	Parallelized user clicks recognition from massive HTTP data based on dependency graph model	China Communications (Volume: 11, Issue: 12, Dec. 2014)	IEEE	CO3,CO4,CO6
118	Discrete Hodge Theory on Graphs: A Tutorial Computing in Science and Engineering (Volume: 15, Issue: 5, Sept.-Oct. 2013) IEEE	CO3,CO4,CO6		
119	Analysis of Shared Memory Priority Queues with Two Discard Levels	(Year: 2007 — Volume: 21, Issue: 4 —) Magazine Article — Publisher: IEEE	IEEE	CO3,CO4,CO6
120	In order to form a more perfect union [minimum spanning tree algorithm]	Computing in Science and Engineering (Volume: 3, Issue: 2, March-April 2001)	IEEE	CO3,CO4,CO6

121	Design specification in Japan: tree-structured charts	IEEE Software (Volume: 6, Issue: 2, March 1989)	IEEE	CO3,CO4,CO6
122	Statistical Test Compaction Using Binary Decision Trees	IEEE Design and Test of Computers (Volume: 23, Issue: 6, June 2006)	IEEE	CO3,CO4,CO6
123	Dream chip 1: a timed priority queue	IEEE Micro (Volume: 13, Issue: 4, Aug. 1993)	IEEE	CO3,CO4,CO6
124	Sorting and searching using ternary CAMs	IEEE Micro (Volume: 23, Issue: 1, Jan.-Feb. 2003)	IEEE	CO2,CO4,CO6
125	Card Sorts to Acquire Requirements	IEEE Software (Volume: 26, Issue: 3, May-June 2009)	IEEE	CO2,CO4,CO6,
126	A constant-time parallel sorting algorithm and its optical implementation	IEEE Micro(Volume: 15, Issue: 3, Jun 1995)	IEEE	CO2,CO4,CO6
127	A sorting classification of parallel rendering	IEEE Computer Graphics and Applications (Volume: 14, Issue: 4, July 1994)	IEEE	CO2,CO4,CO6
128	Rinda: a relational database processor with hardware specialized for searching and sorting	IEEE Micro(Volume: 11, Issue: 6, Dec. 1991)	IEEE	CO3,CO4,CO6
129	Sorting the Web by Subject	IEEE MultiMedia (Volume: 6, Issue: 1, Jan.-March 1999)	IEEE	CO2,CO4,CO6
130	A Query-Based Framework for Searching, Sorting, and Exploring Data Ensembles	Computing in Science and Engineering (Volume: 22, Issue: 2, March-April 2020)	IEEE	CO3,CO5,CO6
131	Neighborhood selection for I/sub DDQ/ outlier screening at wafer sort	IEEE Design and Test of Computers (Volume: 19, Issue: 5, Sep-Oct 2002)	IEEE	CO2,CO4,CO6

132	Spike Sorting: The First Step in Decoding the Brain: The first step in decoding the brain	IEEE Signal Processing Magazine (Volume: 29, Issue: 1, Jan. 2012)	IEEE	CO2,CO4,CO6
133	ACID: Automatic Sort-Map Classification for Interactive Process Diagnosis	IEEE Design & Test of Computers (Volume: 24, Issue: 4, July-Aug. 2007)	IEEE	CO3,CO4,CO6
134	Microsystems Minimal Storage Sorting and Searching Techniques for RAM Applications: a Tutorial	Computer (Volume: 10, Issue: 6, June 1977)	IEEE	CO2,CO4,CO6
135	Recursive algorithms for polynomial transformations	IEEE Circuits and Systems Magazine (Volume: 2, Issue: 3, Sept. 1980)	IEEE	CO3,CO4,CO6
136	Scattering solution of three-dimensional array of patches using the recursive T-matrix algorithms	IEEE Microwave and Guided Wave Letters (Volume: 2, Issue: 5, May 1992)	IEEE	CO3,CO4,CO6
137	Origins of Recursive Function Theory	Annals of the History of Computing (Volume: 3, Issue: 1, Jan.-March 1981)	IEEE	CO3,CO4,CO6
138	A new friends sort algorithm	2009 2nd IEEE International Conference on Computer Science and Information Technology	IEEE	CO3,CO4,CO6
139	Hashing for dynamic and static internal tables	Computer (Volume: 21, Issue: 10, Oct. 1988)	IEEE	CO3,CO4,CO6
140	Efficient algorithms to globally balance a binary search tree	Communications of the ACM(Volume 27Issue 7July 1984)	ACM	CO3,CO4,CO6
141	An insertion algorithm for a minimal internal path length binary search tree	Communications of the ACM (Volume 31 Issue 5 May 1988)	ACM	CO3,CO4,CO6

142	A selective traversal algorithm for binary search trees	Communications of the ACM (Volume 21 Issue 6June 1978)	ACM	CO3,CO4,CO6
143	Multidimensional binary search trees used for associative searching	Communications of the ACM (Volume 18Issue 9Sept. 1975)	ACM	CO3,CO4,CO6
144	An optimal insertion algorithm for one-sided height-balanced binary search trees	Communications of the ACM (Volume 22Issue 9Sept. 1979)	ACM	CO3,CO4,CO6
145	Median split trees: a fast lookup technique for frequently occuring keys	Communications of the ACM (Volume 21Issue 11Nov. 1978)	ACM	CO3,CO4,CO6
146	A comment on the double-chained tree	Communications of the ACM (Volume 15Issue 4April 1972)	ACM	CO3,CO4,CO6
147	Average binary search length for dense ordered lists	Communications of the ACM (Volume 14Issue 9Sept. 1971)	ACM	CO3,CO4,CO6
148	A comparison of tree-balancing algorithms	Communications of the ACM (Volume 20Issue 5May 1977)	ACM	CO3,CO4,CO6
149	Balancing binary trees by internal path reduction	Communications of the ACM (Volume 26Issue 12Dec. 1983)	ACM	CO3,CO4,CO6
150	An empirical study of insertion and deletion in binary search trees	Communications of the ACM (Volume 26Issue 9Sept. 1983)	ACM	CO3,CO4,CO6
151	Randomized binary search technique	Communications of the ACM (Volume 12Issue 2Feb. 1969)	ACM	CO3,CO4,CO6
152	A note on optimal doubly-chained trees	Communications of the ACM (Volume 15Issue 11Nov. 1972)	ACM	CO3,CO4,CO6

153	Randomized binary searching with tree structures	Communications of the ACM (Volume 7Issue 3March 1964)	ACM	CO3,CO4,CO6
154	Deletion in two-dimensional quad trees	Communications of the ACM (Volume 23Issue 12Dec. 1980)	ACM	CO3,CO4,CO6
155	An optimal method for deletion in one-sided height-balanced trees	Communications of the ACM (Volume 21Issue 6June 1978)	ACM	CO3,CO4,CO6
156	Variable length tree structures having minimum average search time	Communications of the ACM (Volume 12Issue 2Feb. 1969)	ACM	CO2,CO4,CO6
157	Self-assessment procedure XIII: a self-assessment procedure dealing with binary search trees and B-trees	Communications of the ACM (Volume 27Issue 5May 1984)	ACM	CO2,CO4,CO6
158	Power trees	Communications of the ACM (Volume 21Issue 11Nov. 1978)	ACM	CO3,CO4,CO6
159	Comment on average binary search length	Communications of the ACM (Volume 15Issue 8Aug. 1972)	ACM	CO3,CO4,CO6
160	Right brother trees	Communications of the ACM (Volume 21Issue 9Sept. 1978)	ACM	CO3,CO4,CO6
161	Optimizing binary trees grown with a sorting algorithm	Communications of the ACM (Volume 15Issue 2Feb. 1972)	ACM	CO3,CO4,CO6
162	A linear algorithm for copying binary trees using bounded workspace	Communications of the ACM (Volume 23Issue 3March 1980)	ACM	CO3,CO4,CO6
163	A numbering system for binary trees	Communications of the ACM (Volume 20Issue 2Feb. 1977)	ACM	CO3,CO4,CO6

164	Variable-width tables with binary-search facility	Communications of the ACM (Volume 1Issue 2Feb. 1958)	ACM	CO3,CO4,CO6
165	On the probability distribution of the values of binary trees	Communications of the ACM (Volume 14Issue 2Feb. 1971)	ACM	CO3,CO4,CO6
166	On-the-fly optimization of data structures	Communications of the ACM (Volume 26Issue 11Nov. 1983)	ACM	CO1
167	Optimizing decision trees through heuristically guided search	Communications of the ACM (Volume 21Issue 12Dec. 1978)	ACM	CO3,CO4,CO6
168	A comment on optimal tree structures	Communications of the ACM (Volume 12Issue 10Oct. 1969)	ACM	CO3,CO4,CO6
169	Searching in a dynamic memory with fast sequential access	Communications of the ACM (Volume 25Issue 7July 1982)	ACM	CO2,CO4,CO6
170	Storage and search properties of a tree-organized memory system	Communications of the ACM (Volume 6Issue 1Jan. 1963)	ACM	CO2,CO4,CO6
171	Interpolation search—a log logN search	Communications of the ACM (Volume 21Issue 7July 1978)	ACM	CO2,CO4,CO6
172	Application of game tree searching techniques to sequential pattern recognition	Communications of the ACM(Volume 14Issue 2Feb. 1971)	ACM	CO2,CO4,CO6
173	Experiments with the M & N tree-searching program	Communications of the ACM (Volume 13Issue 3March)	ACM	CO2,CO4,CO6
174	Algorithm design	Communications of the ACM (Volume 30Issue 3March 1987)	ACM	CO3,CO4,CO6
175	Design of tree structures for efficient querying	Communications of the ACM (Volume 16Issue 9Sept. 1973)	ACM	CO3,CO4,CO6
176	Use of tree structures for processing files	Communications of the ACM (Volume 6Issue 5May 1963)	ACM	CO3,CO4,CO6

177	On shrinking binary picture patterns	Communications of the ACM (Volume 15Issue 1Jan. 1972)	ACM	CO3,CO4,CO6
178	Enterprise Search: Tough Stuff: Why is it that searching an intranet is so much harder than searching the Web?	Queue (Volume 2Issue 2April 2004)	ACM	CO3,CO4,CO6
179	An insertion technique for one-sided height-balanced trees	Communications of the ACM (Volume 19Issue 8Aug. 1976)	ACM	CO3,CO4,CO6
180	Use of tree structures for processing files	Communications of the ACM (Volume 26Issue 1Jan. 1983)	ACM	CO3,CO4,CO6
181	Dynamic hash tables	Communications of the ACM (Volume 31Issue 4April 1988)	ACM	CO3,CO4,CO6
182	Algorithm 422: minimal spanning tree [H]	Communications of the ACM (Volume 15Issue 4April 1972)	ACM	CO3,CO4,CO6
183	A new way to search game trees: technical perspective	Communications of the ACM (Volume 55Issue 3March)	ACM	CO3,CO4,CO6
184	Bit-Tree: a data structure for fast file processing	Communications of the ACM (Volume 35Issue 6June 1992)	ACM	CO3,CO4,CO6
185	On Foster's information storage and retrieval using AVL trees	Communications of the ACM (Volume 15Issue 9Sept. 1972)	ACM	CO3,CO4,CO6
186	Jump searching: a fast sequential search technique	Communications of the ACM (Volume 21Issue 10Oct. 1978)	ACM	CO3,CO4,CO6
187	Renovation of minimum spanning tree algorithms of weighted graph	Ubiquity (Volume 2008Issue FebruaryFebruary 2008)	ACM	CO3,CO4,CO6
188	Algorithm 479: A minimal spanning tree clustering method	Communications of the ACM(Volume 17Issue 6June)	ACM	CO3,CO4,CO6

189	A tree convolution algorithm for the solution of queueing networks	Communications of the ACM (Volume 26Issue 3March 1983)	ACM	CO3,CO4,CO6
190	Insertions and deletions in one-sided height-balanced trees	Communications of the ACM (Volume 21Issue 3March 1978)	ACM	CO3,CO4,CO6
200	The reconstruction of binary patterns from their projections	Communications of the ACM (Volume 14Issue 1Jan. 1971	ACM	CO3,CO4,CO6
201	Performance of height-balanced trees	Communications of the ACM (Volume 19Issue 1Jan. 1976)	ACM	CO3,CO4,CO6
202	Simulations of dynamic sequential search algorithms	Communications of the ACM (Volume 21Issue 9Sept. 1978)	ACM	CO2,CO4,CO6
203	Remark on algorithm 178 [E4]: direct search	Communications of the ACM (Volume 12Issue 11Nov. 1969)	ACM	CO2,CO4,CO6
204	Remark on algorithm 178 [E4]: direct search	Communications of the ACM (Volume 12Issue 11Nov. 1969)	ACM	CO2,CO4,CO6
205	Tree-structured programs	Communications of the ACM (Volume 16Issue 11Nov).	ACM	CO3,CO4,CO6
206	Quadratic search for hash tables of sizes P n	Communications of the ACM (Volume 17Issue 3March 1974)	ACM	CO4,CO5,CO6
207	Weighted increment linear search for scatter tables	Communications of the ACM (Volume 15Issue 12Dec.)	ACM	CO4,CO5,CO6
208	Programming Techniques: Regular expression search algorithm	Communications of the ACM (Volume 11Issue 6June)	ACM	CO4,CO5,CO6
209	Slow search	Communications of the ACM (Volume 57Issue 8August 2014)	ACM	CO2,CO4,CO6

210	An extension of Fibonaccian search to several variables	Communications of the ACM (Volume 6Issue 10Oct. 1963)	ACM	CO3,CO4,CO6
211	On optimal search techniques	Communications of the ACM (Volume 7Issue 1Jan. 1964)	ACM	CO2,CO4,CO6
212	An application of heuristic search methods to edge and contour detection	Communications of the ACM (Volume 19Issue 2Feb. 1976)	ACM	CO3,CO4,CO6
213	Skip lists: a probabilistic alternative to balanced trees	Communications of the ACM (Volume 33Issue 6June)	ACM	CO3,CO4,CO6
214	10 Optimizations on Linear Search: The operations side of the story	QueueVolume 14Issue 4July-August 2016	ACM	CO3,CO4,CO6
215	A class of search-models for machine retrieval	Communications of the ACM (Volume 4Issue 7July 1961)	ACM	CO3,CO4,CO6
216	On constructing the tree of life	XRDS: Crossroads, The ACM Magazine for Students (Volume 20Issue 2Winter 2013)	ACM	CO3,CO4,CO6
217	Web Search—Your Way	Communications of the ACM (Volume 44Issue 12December 2001)	ACM	CO3,CO4,CO6
218	New search challenges and opportunities	Communications of the ACM (Volume 53Issue 1January 2010)	ACM	CO3,CO4,CO6
219	A very fast substring search algorithm	Communications of the ACM (Volume 33Issue 8Aug. 1990)	ACM	CO3,CO4,CO6
220	The grand challenge of computer Go: Monte Carlo tree search and extensions	Communications of the ACM (Volume 55Issue 3March 2012)	ACM	CO3,CO4,CO6
221	Representation of contours and regions for efficient computer search	Communications of the ACM (Volume 16Issue 2Feb.)	ACM	CO3,CO4,CO6

222	A comparison of the decision table and tree	Communications of the ACM (Volume 35Issue 1Jan. 1992)	ACM	CO3,CO4,CO6
223	Optimal pagination of B-trees with variable-length items	Communications of the ACM (Volume 27Issue 3March 1984)	ACM	CO3,CO4,CO6
224	Algorithm 387: Function mimimization and linear search	Communications of the ACM (Volume 13Issue 8Aug. 1970)	ACM	CO3,CO4,CO6
225	An empirical comparison of priority-queue and event-set implementations	Communications of the ACM (Volume 29Issue 4April 1986)	ACM	CO3,CO4,CO6
226	Application of splay trees to data compression	Communications of the ACM (Volume 31Issue 8Aug. 1988)	ACM	CO3,CO4,CO6
227	Full table quadratic searching for scatter storage	Communications of the ACM (Volume 13Issue 8Aug. 1970)	ACM	CO3,CO4,CO6
228	Ubiquity symposium: Evolutionary computation and the processes of life: what the no free lunch theorems really mean: how to improve search algorithms	Ubiquity(Volume 2013Issue DecemberDecember 2013)	ACM	CO3,CO4,CO6
229	A new approach to text searching	Communications of the ACM (Volume 35Issue 10Oct. 1992)	ACM	CO3,CO4,CO6
230	The new searchers	Communications of the ACM (Volume 52Issue 8August 2009)	ACM	CO3,CO4,CO6
231	File structures using hashing functions	Communications of the ACM (Volume 13Issue 7July 1970)	ACM	CO3,CO4,CO6
232	A data structure for manipulating priority queues	Communications of the ACM (Volume 21Issue 4April 1978)	ACM	CO3,CO4,CO6

233	Compressed tries	Communications of the ACM (Volume 19Issue 7July 1976)	ACM	CO3,CO4,CO6
234	TID—a translation invariant data structure for storing images	Communications of the ACM (Volume 29Issue 5May 1986)	ACM	CO3,CO4,CO6
235	Distributed computation on graphs: shortest path algorithms	Communications of the ACM (Volume 25Issue 11Nov 1982)	ACM	CO3,CO4,CO6
236	Technical correspondence: On B-trees re-examined	Communications of the ACM (Volume 21Issue 7July 1978)	ACM	CO3,CO4,CO6
237	Pseudochaining in hash tables	Communications of the ACM (Volume 21Issue 7July 1978)	ACM	CO3,CO4,CO6
238	Implementations for coalesced hashing	Communications of the ACM (Volume 25Issue 12Dec 1982)	ACM	CO3,CO4,CO6
239	Reciprocal hashing: a method for generating minimal perfect hashing functions	Communications of the (ACMVolume 24Issue 12Dec. 1981)	ACM	CO3,CO4,CO6
240	Perfect hashing functions: a single probe retrieving method for static sets	Communications of the ACM (Volume 20Issue 11Nov. 1977)	ACM	CO3,CO4,CO6
241	Comments on perfect hashing functions: a single probe retrieving method for static sets	Communications of the ACM (Volume 22Issue 2Feb. 1979)	ACM	CO3,CO4,CO6
242	Reducing the retrieval time of hashing method by using predictors	Communications of the ACM (Volume 26Issue 12Dec. 1983)	ACM	CO3,CO4,CO6
243	Implementation of the substring test by hashing	Communications of the ACM (Volume 14Issue 12Dec. 1971)	ACM	CO3,CO4,CO6
244	Minimal perfect hash functions made simple	Communications of the ACM (Volume 23Issue 1Jan. 1980)	ACM	CO3,CO4,CO6

245	Reducing dictionary size by using a hashing technique	Communications of the ACM (Volume 25Issue 6June 1982)	ACM	CO3,CO4,CO6
246	Practical minimal perfect hash functions for large databases	Communications of the ACM (Volume 35Issue 1Jan. 1992)	ACM	CO3,CO4,CO6
247	The linear quotient hash code	Communications of the ACM (Volume 13Issue 11Nov 1970)	ACM	CO3,CO4,CO6
248	The study of an ordered minimal perfect hashing scheme	Communications of the ACM (Volume 27Issue 4April 1984)	ACM	CO3,CO4,CO6
249	Concurrent operations on extendible hashing and its performance	Communications of the ACM (Volume 33Issue 6June 1990)	ACM	CO3,CO4,CO6
250	The reallocation of hash-coded tables	Communications of the ACM (Volume 16Issue 1Jan. 1973)	ACM	CO9, CO11,CO12
251	Comment on Bell's quadratic quotient method for hash coded searching	Communications of the ACM (Volume 13Issue 9Sept. 1970)	ACM	CO3,CO4,CO6
252	Fast parallel sorting algorithms	Communications of the ACM (Volume 21Issue 8Aug. 1978)	ACM	CO3,CO4,CO6
253	Relaxed heaps: an alternative to Fibonacci heaps with applications to parallel computation	Communications of the ACM (Volume 31Issue 11Nov. 1988)	ACM	CO3,CO4,CO6
254	BabelVision: better image searching through shared annotations	Interactions (Volume 11Issue 2March + April 2004)	ACM	CO3,CO4,CO6
255	sort Programming Technique: An improved hash code for scatter storage	Communications of the ACM, (Volume 11, Issue 1Jan. 1968)	ACM	CO3,CO4,CO6

256	Remark on algorithm 175: Shuttle sort	Communications of the ACM (Volume 7Issue 5May 1964)	ACM	CO3,CO4,CO6
257	Merge sort algorithm [M1]	Communications of the ACM (Volume 15Issue 5May 1972)	ACM	CO3,CO4,CO6
258	Length of strings for a merge sort	Communications of the ACM (Volume 6Issue 11Nov. 1963)	ACM	CO3,CO4,CO6
259	Buffer allocation in merge-sorting	Communications of the ACM (Volume 14Issue 7July 1971)	ACM	CO3,CO4,CO6
260	Letters to the editor: three letters on merging	Communications of the ACM (Volume 6Issue 10Oct. 1963)	ACM	CO3,CO4,CO6
261	More on merging	Communications of the ACM (Volume 7Issue 5May 1964)	ACM	CO3,CO4,CO6
262	A comparison between the polyphase and oscillating sort techniques	Communications of the ACM (Volume 6Issue 5May 1963)	ACM	CO3,CO4,CO6
263	A generalized partial pass block sort	Communications of the ACM (Volume 11Issue 7July 1968)	ACM	CO3,CO4,CO6
264	Optimizing the polyphase sort	Communications of the ACM (Volume 14Issue 11Nov. 1971)	ACM	CO3,CO4,CO6
265	Best sorting algorithm for nearly sorted lists	Communications of the ACM (Volume 23Issue 11Nov. 1980)	ACM	CO2,CO4,CO6
266	A generalized polyphase merge algorithm	Communications of the ACM (Volume 4Issue 8Aug. 1961)	ACM	CO2,CO4,CO6
267	On polyphase sort	Communications of the ACM (Volume 7Issue 5May 1964)	ACM	CO3,CO4,CO6
268	Design and characteristics of a variable-length record sort using new fixed-length record sorting techniques	Communications of the ACM (Volume 6Issue 5May 1963)	ACM	CO2,CO4,CO6

269	String distribution for the polyphase sort	Communications of the ACM (Volume 6Issue 5May 1963)	ACM	CO2,CO4,CO6
270	A dispersion pass algorithm for the polyphase merge	Communications of the ACM (Volume 5Issue 10Oct).	ACM	CO3,CO4,CO6
271	Algorithm 23: MATH SORT	Communications of the ACM (Volume 3Issue 11Nov. 1960)	ACM	CO2,CO4,CO6
272	Algorithm 175: shuttle sort	Communications of the ACM (Volume 6Issue 6June 1963)	ACM	CO3,CO4,CO6
273	A variation on sorting by address calculation	Communications of the ACM (Volume 13Issue 2Feb 1970)	ACM	CO3,CO4,CO6
274	A method of comparing the time requirements of sorting methods	Communications of the ACM (Volume 6Issue 5May 1963)	ACM	CO3,CO4,CO6
275	Sorting in a paging environment	Communications of the ACM (Volume 13Issue 8Aug. 1970)	ACM	CO3,CO4,CO6
276	Sorting on a mesh-connected parallel computer	Communications of the ACM (Volume 20Issue 4April 1977)	ACM	CO3,CO4,CO6
277	Read-backward polyphase sorting	Communications of the ACM (Volume 6Issue 5May 1963)	ACM	CO3,CO4,CO6
278	Sorting X + Y	Communications of the ACM (Volume 18Issue 6June 1975)	ACM	CO3,CO4,CO6
279	An inverted taxonomy of sorting algorithms	Communications of the ACM (Volume 28Issue 1Jan.)	ACM	CO3,CO4,CO6
280	Polyphase sorting with overlapped rewind	Communications of the ACM (Volume 7Issue 3March 1964)	ACM	CO3,CO4,CO6
281	Optimum merging from mass storage	Communications of the ACM (Volume 13Issue 12Dec. 1970)	ACM	CO3,CO4,CO6

282	Some characteristics of sorting computing systems using random access storage devices	Communications of the ACM (Volume 6Issue 5May 1963)	ACM	CO3,CO4,CO6
283	Parallelism in tape-sorting	Communications of the ACM (Volume 17Issue 4April 1974)	ACM	CO3,CO4,CO6
284	The COBOL sorting verb	Communications of the ACM (Volume 6Issue 5May 1963)	ACM	CO3,CO4,CO6
285	Practical in-place merging	Communications of the ACM (Volume 31Issue 3March 1988)	ACM	CO3,CO4,CO6
286	Multiphase sorting	Communications of the ACM (Volume 6Issue 5May)	ACM	CO3,CO4,CO6
287	The input/output complexity of sorting and related problems	Communications of the ACM (Volume 31Issue 9Sept. 1988)	ACM	CO3,CO4,CO6
288	On the expected lengths of sequences generated in sorting by replacement selecting	Communications of the ACM (Volume 12Issue 7July 1969)	ACM	CO3,CO4,CO6
289	An estimation of the relative efficiency of two internal sorting methods	Communications of the ACM (Volume 3Issue 11Nov. 1960)	ACM	CO3,CO4,CO6
290	A sorting problem and its complexity	Communications of the ACM (Volume 15Issue 6June 1972)	ACM	CO3,CO4,CO6
291	Sorting with large volume, random access, drum storage	Communications of the ACM (Volume 6Issue 5May 1963)	ACM	CO3,CO4,CO6
292	Algorithm 347: an efficient algorithm for sorting with minimal storage [M1]	Communications of the ACM (Volume 12Issue 3March)	ACM	CO3,CO4,CO6
293	A class of sorting algorithms based on Quicksort	Communications of the ACM (Volume 28Issue 4April)	ACM	CO3,CO4,CO6
294	Internal and tape sorting using the replacement-selection technique	Communications of the ACM (Volume 6Issue 5May)	ACM	CO3,CO4,CO6

295	Parallel culling and sorting based on adaptive static balancing	Computers in Entertainment (Volume 7Issue 4December 2009)	ACM	CO3,CO4,CO6
296	Algorithm 410: Partial sorting	Communications of the ACM (Volume 14Issue 5May 1971)	ACM	CO3,CO4,CO6
297	Merging with parallel processors	Communications of the ACM (Volume 18Issue 10Oct. 1975)	ACM	CO3,CO4,CO6
298	Conversion, reconversion and comparison techniques in variable-length sorting	Communications of the ACM (Volume 6Issue 5May 1963)	ACM	CO3,CO4,CO6
299	Organization and structure of data on disk file memory systems for efficient sorting and other data processing programs	Communications of the ACM (Volume 6Issue 5May 1963)	ACM	CO2,CO4,CO6
300	An encoding method for multifield sorting and indexing	Communications of the ACM (Volume 20Issue 11Nov. 1977)	ACM	CO2,CO4,CO6
301	Sorting on computers	Communications of the ACM (Volume 6Issue 5May 1963)	ACM	CO2,CO4,CO6
302	Sorting nonredundant files—techniques used in the FACT compiler	Communications of the ACM (Volume 6Issue 5May 1963)	ACM	CO2,CO4,CO6
303	Sorting by natural selection	Communications of the ACM (Volume 15Issue 10Oct. 1972)	ACM	CO2,CO4,CO6
304	An empirical study of minimal storage sorting	Communications of the ACM (Volume 6Issue 5May 1963)	ACM	CO2,CO4,CO6
305	Disk file sorting	Communications of the ACM (Volume 6Issue 6June 1963)	ACM	CO2,CO4,CO6
306	Remark on algorithm 347: An efficient algorithm for sorting with minimal storage	Communications of the ACM (Volume 13Issue 10Oct. 1970)	ACM	CO3,CO4,CO6

307	A high-speed sorting procedure	Communications of the ACM (Volume 2Issue 7July 1959)	ACM	CO2,CO4,CO6
308	Internal sorting	Communications of the ACM (Volume 7Issue 9Sep. 1964)	ACM	CO2,CO4,CO6
309	Programming pearls: how to sort	Communications of the ACM Volume 27Issue 4April 1984	ACM	CO3,CO4,CO6
310	A high-speed sorting procedure	Communications of the ACM (Volume 3Issue 1Jan. 1960)	ACM	CO2,CO4,CO6
311	Topological sorting of large networks	Communications of the ACM (Volume 5Issue 11Nov. 1962)	ACM	CO3,CO4,CO6
312	RKPianGraphSort: a graph based sorting algorithm	OctoberOctober 2007	ACM	CO3,CO4,CO6
313	Letters to the editor: a two-tape-unit	Communications of the ACM (Volume 8Issue 11Nov.)	ACM	CO3,CO4,CO6
314	Sorting by replacement selecting	Communications of the ACM (Volume 10Issue 2Feb. 1967)	ACM	CO2,CO4,CO6
315	Sorting out searching: a user-interface framework for text searches	Communications of the ACM (Volume 41Issue 4April 1998)	ACM	CO2,CO4,CO6
316	Some performance tests of “quicksort” and descendants	Communications of the ACM (Volume 17Issue 3March 1974)	ACM	CO2,CO4,CO6
317	Implementing Quicksort programs	Communications of the ACM (Volume 21Issue 10Oct.)	ACM	CO2,CO4,CO6
318	Pracniques: Meansort	Communications of the ACM (Volume 26Issue 4April 1983)	ACM	CO3,CO4,CO6
319	Increasing the efficiency of quicksort	Communications of the ACM (Volume 13Issue 9Sept. 1970)	ACM	CO3,CO4,CO6

320	Pracniques: Meansort	Communications of the ACM (Volume 26Issue 4April 1983)	ACM	CO3,CO4,CO6

Course Coordinator: **HOD ECE**
Dr V.Sitharamulu, Associate Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**FLUID DYNAMICS LABORATORY**				
Course Code	AAEB05				
Program	B.Tech				
Semester	III				
Course Type	Laboratory				
Regulation	IARE R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Mr. V Phaninder Reddy, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB03	III	Fluid Dynamics

II COURSE OVERVIEW:

The Fluid mechanics and Hydraulic machines laboratory is designed to examine the properties of fluids and to conduct experiments involving both incompressible and compressible flow.This course will also provide the fundamental knowledge on basic measurements and devices used in fluid dynamic application. It is an introductory course where flow behavior, fluid forces and analysis tools are introduced.The course also discusses about various flow measuring devices, pumps, turbines used in fluid dynamic application and measurement of their performance characteristics. Students are expected to get hands on experience on investigating the fundamentals of fluid statics as well as kinematics and kinetics of fluid flow and operation of turbo machineries.

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	The types of fluids, properties and behaviour under static and dynamic conditions of closed conduit and external flow systems.
II	The operating principle of various turbo machinery and analyze their performance characteristics under various operating conditions.
III	The measurement of flow rate through various internal and external flow systems.

VII COURSE OUTCOMES:

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

CO 1	**Interpret** the concept of calibrating orifice and venturi meter for reducing the uncertainty in the discharge coefficient. .	Apply
CO 2	**Make use of** pipe friction test apparatus to measure the friction factor under a range of flow rates and flow regimes for calculating major loses in closed pipes	Apply
CO 3	**Demonstrate** the verification of Bernoulli's theorem for incompressible steady continuous flow . for regulating pipe flow across crossection and datum	Understand
CO 4	**Identify** the critical Reynolds number using Reynolds apparatus for illustrating the transition of laminal flow into turbulent flow.	Apply
CO 5	**Make use of** jet impact apparatus for investigating the reaction forces produced by the change in momentum.	Apply
CO 6	**Distinguish** the performance characteristics of turbo machinery to various operating conditions for calculating eficacy of turbines under specific applications	Analyze

VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIA
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Utilize the concept of calibration to a considerable extent appreciate (understanding) their importance and applicability (apply) in solving (complex) fluid flow engineering problems by applying the **principles of Mathematics and Engineering**	3
	PO 2	Understand the (given **problem statement**) calibration procedure for (provided **information and data**) in reaching substantiated conclusions by the interpretation of results	3
	PSO 3	Apply (**knowledge**) properties, various types and patterns of fluid flow configurations (apply) for solving design problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 2	PO 1	Explain (understanding) various effects of viscosity in flow through pipes and apply Newtons law of viscosity, in calculating energy loss by applying **principles of Mathematics, Science and Engineering**	3
	PO 5	Understand the (given **problem statement**) effects of viscosity, and capillary rise for the bodies immersed in fluids. (from the provided **information**) in solving analysis problems.	2
	PSO 3	Apply (**knowledge**) Newtons law of viscosity (understanding) in body, under different inlet conditions in (apply) solving flow through pipes by applying the principles of **Mathematics, Science and Engineering**	3
CO 3	PO 1	Summarize (**knowledge**) the concept of pressure measuring devices applications and effect of buoyancy on submerged bodies (understanding) their importance and applicability (apply) in solving (complex) fluid flow engineering problems by applying the textbfprinciples of Mathematics, Science and Engineering	3
	PO 3	Understand the given **problem statement** and formulate (complex) of pressure measuring devices applications and effect of buoyancy on submerged bodies (understanding) their importance and applicability (apply) in solving (**complex**) fluid flow engineering problems from the provided information and substantiate with the **interpretation** of variations in the **results**.	3
	PSO 3	Apply (knowledge) various effects of viscosity, static pressure, surface tension, Newton's law of viscosity, pressure difference and capillary rise (apply) in solving aircraft analysis problems by applying the **principles of Mathematics, Science and Engineering**	3

CO 4	PO 1	Recognize (knowledge) the importance and application (apply) of dimensions, units and dimensional homogeneity in solving (complex) engineering problems with specific emphasis to fluid mechanics by applying the **principles of Mathematics, Science and Engineering**	3
	PO 5	Understand the given **problem statement and formulate** the dimensional analysis and similarity parameters for predicting physical parameters that govern fluid systems in designing prototypes devices	2
	PSO 3	Apply (knowledge) concept of dimensional analysis and similarity parameters for predicting physical parameters (understanding) for the fluid flow analysis used in designing prototypes devices (apply) solving design problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 5	PO 1	Apply the basic conservation laws of science for various phenomena of fluid systems and use **mathematical principles** for deriving (complex) fluid flow engineering equations by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals** of fluid mechanics.	3
	PO 3	Understand the given **problem statement** and formulate (complex) fluid flow engineering phenomena and system for deriving various governing equations of fluid mechanics from the provided information and substantiate with the **interpretation** of variations in the results.	2
	PO 5	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of fluid mechanics.	2
	PSO 3	Apply (knowledge) concept of dimensional analysis and similarity parameters for predicting physical parameters (understanding) for the fluid flow analysis used in designing prototypes devices (apply) solving design problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 6	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** principles to understand the Bernoulli Equation for real flows and its applications	2
	PO 3	Using Euler equation of motion derive the Bernoulli equation to analyze complex fluid flow problems using **principles of mathematics and engineering sciences.**	3
CO 7	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** for determining unit indicators, and performance of hydraulic machines such as speed, discharge and power numbers etc for designing the new equipment's as per the requirements	2

	PO 5	Using first **principles of Sciences and Engineering fundamentals** understand the concept of unit indicators, and performance of hydraulic machines such as speed, discharge and power numbers for designing desired equipment's.	2
	PSO 3	Extend the focus to **understand the innovative and dynamic challenges** involves in evaluation of hydraulic machine performance.	1

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

COURSE OUTCOMES	PROGRAM OUTCOMES			PSO'S
	PO 1	PO 3	PO 5	PSO 3
CO 1	2	3		3
CO 2	2		2	3
CO 3	2	3		3
CO 4	2		2	3
CO 5	2	3	2	3
CO 6	2	3		
CO 7	2		2	3

XIII ASSESSMENT METHODOLOGY DIRECT:

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

XIV ASSESSMENT METHODOLOGY INDIRECT:

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

XV SYLLABUS:

WEEK I	**CALIBRATION**
	Calibration of Venturimeter and Orifice meter.
WEEK II	**PIPE FLOW LOSSES**
	Determination of pipe flow losses in rectangular and circular pipes
WEEK III	**BERNOULLI'S THEOREM**
	Verification of Bernoulli's theorem.
WEEK IV	**REYNOLDS EXPERIMENT**
	Determination of Reynolds Number of fluid flow
WEEK V	**IMPACT OF JET ON VANES**

	Study Impact of jet on Vanes.
WEEK VI	**CENTRIFUGAL PUMPS**
	Performance test on centrifugal pumps.
WEEK VII	**RECIPROCATING PUMPS**
	Performance test on Reciprocatng pumps.
WEEK VIII	**PELTON WHEEL TURBINE**
	Performance test on Pelton Wheel Turbine.
WEEK IX	**FRANCIS TURBINE**
	Performance test on Francis turbine.
WEEK X	**FLOW THROUGH WEIRS**
	Rate of discharge Flow through Weirs
WEEK XI	**FLOW THROUGH NOTCH**
	Flow through rectangular and V-Notch
WEEK XII	**FLOW THOUGH ORIFICE MOUTH PIECE**
	Flow analysis of different shapes of mouth pieces

TEXTBOOKS

1. Sutton, G.P., et al., —Rocket Propulsion Elements, John Wiley Sons Inc., New York, 1993
2. Martin J.L Turner , Rocket Space Craft Propulsion, Springers oraxis publishing, 2001

REFERENCE BOOKS:

1. Mathur, M., and Sharma, R.P., —Gas Turbines and Jet and Rocket Propulsion, Standard Publishers, New Delhi 1998
2. Cornelisse, J.W., Rocket Propulsion and Space Dynamics, J.W., Freeman & Co. Ltd., London, 1982.
3. Parker, E.R., Materials for Missiles and Spacecraft, McGraw-Hill Book Co. Inc., 1982.

XVI COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Calibration of Venturimeter and Orifice meter.	CO 1	R1: 1.2
2	Determination of pipe flow losses in rectangular and circular pipes.	CO 2	R2: 3.5
3	Verification of Bernoulli's theorem	CO 3	R1: 3.4
4	Determination of Reynolds Number of fluid flow	CO 4	R1: 2.2
5	Determine the reaction forces produced by the change in momentum.	CO 5	R1: 2.4
6	Determine the efficiencyand draw theperformance curves ofcentrifugal pump.	CO 6	R3: 4.5
7	Determine the efficiencyand draw theperformance curves of reciprocating pump.	CO 6	R3: 4.6

8	Determine the performance characteristics of pelton wheel under constant head.	CO 6	R2: 5.1
9	Determine the performance characteristics of Francis turbine.	CO 6	R2: 5.2
10	Determine the rate of flow through weir.	CO 7	R1: 7.1
11	Determine the rate of flow through Nothches.	CO 7	R1:7.2
12	Determine the rate of flow through a Orifice meter	CO 7	R1:7.3

XVII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

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

Signature of Course Coordinator **HOD,AE**

Dr. Maruthupandiyan K, Associate Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**MECHANICS OF SOLIDS**				
Course Code	AAEB04				
Program	B.Tech				
Semester	III	AE			
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	2	1
Course Coordinator	Mr S Devaraj, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB03	II	Engineering Mechanics

II COURSE OVERVIEW:

Mechanics of solids deals with deformable solids, requires basic knowledge of principles of mechanics from Engineering Mechanics course and acts as a pre-requisite to the advanced courses on Aircraft structures and Analysis of aircraft structures. This course introduces the concepts of simple stresses, strains and principal stresses on deformable solids and focuses on the analysis of members subjected to axial, bending, and torsional loads. In a nutshell, the course aims at developing the skill to solve engineering problems on strength of materials. Eventually, through this course content, engineers can analyze the response of various structural members under different loading conditions and design the same, satisfying the safety and serviceability conditions.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Mechanics of Solids	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
10 %	Remember
30 %	Understand
50 %	Apply
10 %	Analyze

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

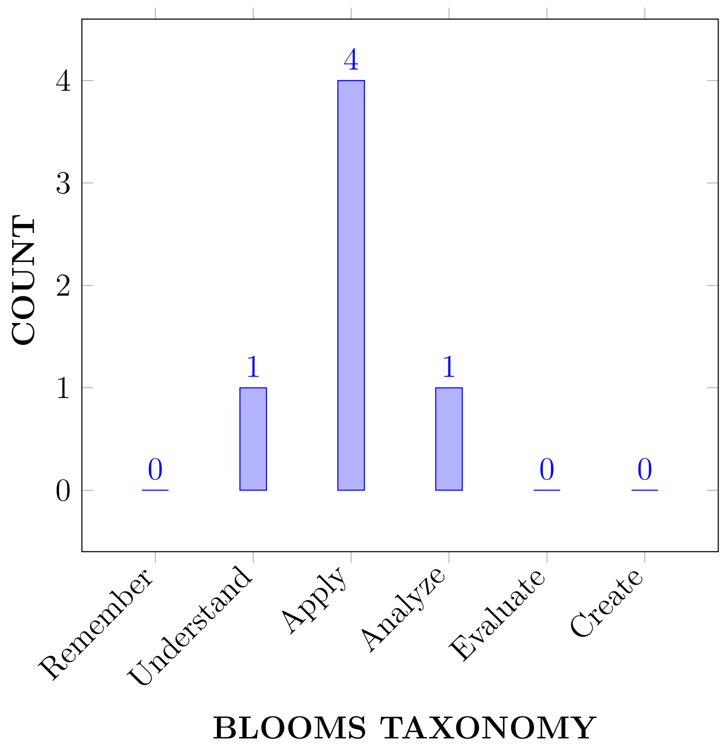
I	The concepts of mechanics of deformable solids and their constitutive relations (including stress – strain relations), principal stresses and strains and resilience produced under various loading conditions for determining the strength of aircraft structures.
II	The methods of determining shear force - bending moment, twisting moment, flexural Stresses, shear stresses, subjected to various loadings and boundary conditions, for designing the shape, size and material of aircraft components.
III	The methods for determining the slope and deflection of different types of beams subjected to various loading conditions for determining the strength of aircraft structures.
IV	The twisting moment, torsion, torque, principal stress and strains for designing the shaft and rods for analysis of aircraft structures.

VII COURSE OUTCOMES:

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

CO 1	**Understand** the concepts of stress-strain, material constitutional relationship and strain energy for solving the stresses and strain induced in the body under various loading conditions	Understand
CO 2	**Illustrate** the shear force and bending moment in beams, for analyzing the structural behavior based on different loading conditions	Apply
CO 3	**Analyze** the effects of various loading conditions on symmetric and un symmetric beams for determining the flexural stresses.	Apply
CO 4	**Illustrate** the effects of various loading conditions on symmetric and un symmetric beams for determining the shear stresses.	Apply
CO 5	**Make use of** different methods such as for finding deflections under different loading conditions.	Apply
CO 6	**Utilize** the concept of stresses on inclined planes using graphical and analytical method for further comprehension of aircraft structures.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/SEE/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/SEE/AAT
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 2	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	1	CIE/ SEE/AAT

3 = High; 2 = Medium; 1 = Low

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

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

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Explain the basic properties of materials and the concept of stress and strain using the knowledge of **mathematics and engineering fundamentals.**	2
	PO 2	**Formulates the problem** to determinate stresses and strains of uniform and stepped bars for **development of solution** to finding deformation **analyse the complex engineering problems** using the **principles of mathematics and engineering sciences.**	5
	PSO 2	Computes tensile and compressive strength of members, with the help of the **knowledge of elastic properties of materials.**	1
CO 2	PO 1	Calculates the bending moment, shear force, and draw bending moment and shear force diagrams by making use of the **mathematical principles and engineering fundamentals.**	2
	PO 2	**Formulates the problem** on determinate beams for **development of solution** to find bending moment and shear force and **analyse the complex engineering problems** using the **principles of mathematics and engineering sciences.**	5
	PSO 2	Determine the shear force and bending moment values for different types of beams under different loading conditions with help of the **knowledge of elastic properties of materials.**	1
CO 3	PO 1	Apply the knowledge of **mathematics, engineering fundamentals** for computing the bending stress distribution across the section of simple and composite bars.	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 2	**Formulates the problem** to determine the bending moment for **development of solution** to find bending moment distribution accross the depth of the beam to **analyse the complex engineering problems** using the **principles of mathematics and engineering sciences.**	5
	PSO 2	Compute the bending stress distribution across the section of simple and composite beams with help of the **knowledge of elastic properties of materials.**	1
CO 4	PO 1	Apply the knowledge of **mathematics, engineering fundamentals** for computing the shear stress distribution across the section of simple and composite bars.	2
	PO 2	**Formulates the problem** to determine the shear stress for **development of solution** to find shear stress distribution accross the depth of the beam to **analyse the complex engineering problems** using the **principles of mathematics and engineering sciences.**	5
CO 5	PO 1	Use the **mathematical principles and engineering fundamentals** in understanding the relationship between slope and deflection, and determine the values by using the double integration and Macaulay's methods for various beams under different loading conditions.	2
	PO 2	**Formulate the problem** on different types of beams with various load conditions for **development of solution** to find slopes and deflection and **analyse the complex engineering problems** using the **principles of mathematics and engineering sciences.**	5
CO 6	PO 1	Understand the concepts of principal stresses and strains and apply Mohr's circle of stresses for solving the two-dimensional stress problems, making use of the knowledge of **mathematics, engineering fundamentals**	2
	PO 2	Determine the principal stresses and strains in a structural member, by **formulating the problem** for **development of solution**, also **analyse the complex engineering problems** using the **principles of mathematics and engineering sciences.**	5
	PO 12	Recognize the importance of strength and stability of structural members, under varying load conditions and tries to **enhance design skill** for improving the strength and stability of existing structures towards **future advancement and lifelong learning.**	3

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

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.6	50	-	-	-	-	-	-	-	-	-	-	-	10	-
CO 2	66.6	50	-	-	-	-	-	-	-	-	-	-	-	10	-
CO 3	66.6	50	-	-	-	-	-	-	-	-	-	-	-	10	-
CO 4	66.6	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.6	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.6	50	-	-	-	-	-	-	-	-	-	37.5	-	-	-

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

0 - 0≤ C≤ 5% – No correlation

1-5 <C≤ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

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

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

XVI ASSESSMENT METHODOLOGY DIRECT:

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

XVII ASSESSMENT METHODOLOGY INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**SIMPLE STRESSES AND STRAINS**
	Elasticity and plasticity, types of stresses and strains, Saint Venant"s principle, Hooke"s law, stress, strain diagram for mild steel, working stress, factor of safety, lateral strain, Poisson"s ratio & volumetric strain, Elastic moduli & the relationship between them, bars of varying section, composite bars, temperature stresses; Strain energy and resilience, gradual, sudden, impact loadings
MODULE II	**SHEAR FORCE AND BENDING MOMENT**
	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., uniformly varying loads and combination of these loads, point of contra flexure, relation between S.F., B.M.
MODULE III	**FLEXURAL, SHEAR STRESSES**
	Flexural Stresses: Theory of simple bending, assumptions, derivation of bending equation, neutral axis, determination bending stresses, section modulus of rectangular and circular sections (Solid and Hollow), I, T, angle and channel sections, design of simple beam sections, beams of uniform strength. **Shear Stresses**: Derivation of formula, shear stress distribution across various beams sections like rectangular, circular, triangular, I, T and angle sections.
MODULE IV	**DEFLECTION OF BEAMS**
	Bending into a circular arc, slope, deflection and radius of curvature, differential equation for the elastic line of a beam, double integration and Macaulay"s methods, determination of slope and deflection for cantilever and simply supported beams, over hanging beams, propped beams and cantilevers subjected to point loads, U.D.L and uniformly varying load. Beams of variable cross-sections

MODULE V	**TORSION OF CIRCULAR SHAFTS, PRINCIPAL STRESS AND STRAINS**
	Torsion of circular Shafts: Introduction, relation between twisting moment twist and shear stress, torque, power, rotational speed, polar moment of inertia, torsional shear stress and polar moment of inertia for solid and hollow circular shafts, design of shafts, combined bending and torsion. **Principal Stress and Strains:** Stress components of inclined planes, Biaxial stress with state of simple shear, circular diagram of stress, Mohr circle, principal strains: Computation of principal stresses form principal strains, strain in an inclined direction, Mohr circle of strain, strain measurement, strain Rosettes.

TEXTBOOKS

1. R. K. Bansal, "A Textbook of Strength of Materials", Laxmi publications Pvt. Ltd., New Delhi, 2nd Edition, 2007.
2. F. Beer, E. R. Johnston, J. DeWolf, "Mechanics of Materials", Tata McGraw-Hill Publishing Company Ltd., New Delhi, India, 1st Edition, 2008
3. S. S. Bhavikatti, "Strength of Materials", Vikas Publishing House Pvt. Ltd., New Delhi, 5th Edition, 2013.

REFERENCE BOOKS:

1. B. C. Punmia, Ashok K Jain and Arun K Jain, "Mechanics of Materials", Laxmi Publications Pvt. Ltd., New Delhi, 12th Edition, 2007.
2. R. Subramanian, "Strength of Materials", Oxford University Press, 2nd Edition, 2010
3. Hibbeler, R. C., "Mechanics of Materials", East Rutherford, NJ: Pearson Prentice Hall, 6th Edition, 2004.

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	References
OBE DISCUSSION			
1	Course Objectives, Course Outcomes, Program Objectives and Program Outcomes		
CONTENT DELIVERY (THEORY)			
1	Introduction to Strength of Materials. Basic principles of mechanics.	CO 1	R1: 1.1
2	Simple stresses and strains- Types of stress and strains -	CO 1	T1: 1.1 to 1.6 R1: 2.1,2.4
3	Stress-strain diagram for mild steel – Working stress – Factor of safety.	CO 1	T1: 1.6 R1: 2.5
4	Mechanical properties of materials and Hook's Law safety.	CO 1	T1: 1.6 R1: 2.5

5	Lateral strain, Poisson's ratio and volumetric strain – Elastic moduli and the relationship between them.	CO 1	T1: 1.7 R1: 3.1,3.13
6	Bars of uniform and varying sections – Numerical examples	CO 1	T1: 1.10 R1: 2.7
7	Composite bars – stress-strain relationship for temperature.	CO 1	T1: 1.13, 1.14 R1: 2.15, 2.18
8	Strain Energy, Resilience – Gradual, sudden, impact and shock loadings	CO 1	T1: 4.3, 4.4 R1: 6.2, 6.4
9	Derivations – Gradual, sudden, impact and shock loadings	CO 1	T1: 4.3, 4.4 R1: 6.2, 6.4
10	Derivations – impact and shock loadings	CO 1	T1: 4.3, 4.4 R1: 6.2, 6.4
11	Definition of beam – Types of beams	CO 2	T1:6.3, 6.4, 6.5 R1: 9.2 to 9.5
12	Types of loads and – Concept of shear force and bending moment.	CO 2	T1:6.3, 6.4, 6.5 R1: 9.2 to 9.5
13	Derivation of S.F and B.M diagrams for cantilever beam subjected to point load at its free end and mid span condition.	CO 2	T1: 6.7, 6.8 R1: 9.5
14	Derivation of S.F and B.M diagrams for cantilever beam subjected to multiple point loads.	CO 2	T1: 6.7, 6.8 R1: 9.5
15	Derivation of S.F and B.M diagrams for cantilever beam subjected to uniformly distributed load (UDL)over its entire span and half span conditions.	CO 2	T1: 6.7, 6.8 R1: 9.5
16	Derivation of S.F and B.M diagrams for cantilever beam subjected to combination of point load uniformly distributed load.	CO 2	T1: 6.7, 6.8 R1: 9.5
17	Derivation of S.F and B.M diagrams for cantilever beam subjected to uniformly varying load (UVL)over its entire span and half span conditions.	CO 2	T1: 6.7, 6.8 R1: 9.5
18	Derivation of S.F and B.M diagrams for cantilever beam subjected to combination all types of loads.	CO 2	T1: 6.7, 6.8 R1: 9.5
19	Derivation of S.F and B.M diagrams for simply supported beam (SSB)subjected to point load at its mid span and any point rather than mid span conditions.	CO 2	T1: 6.7, 6.8 R1: 9.5
20	Derivation of S.F and B.M diagrams for simply supported beam (SSB) subjected to multiple point loads.	CO 2	T1: 6.7, 6.8 R1: 9.5

21	Derivation of S.F and B.M diagrams for simply supported beam (SSB) subjected to uniformly distributed load (UDL)over its entire span and half span conditions.	CO 2	T1: 6.7, 6.8 R1: 9.5
22	Derivation of S.F and B.M diagrams for simply supported beam (SSB) subjected to combination of point load uniformly distributed load.	CO 2	T1: 6.7, 6.8 R1: 9.5
23	Derivation of S.F and B.M diagrams for simply supported beam (SSB) subjected to uniformly varying load (UVL)over its entire span and half span conditions.	CO 2	T1: 6.7, 6.8 R1: 9.5
24	Derivation of S.F and B.M diagrams for simply supported beam (SSB) subjected to combination all types of loads.	CO 2	T1: 6.7, 6.8 R1: 9.5
25	Derivation of S.F and B.M diagrams for over hanged beam (SSB) subjected to combination all types of loads.	CO 2	T1: 6.7, 6.8 R1: 9.5
26	Determination of point of contraflexture for the beam carrying different loads on it.	CO 2	T1: 6.7, 6.8 R1: 9.5
27	Theory of simple bending. Assumptions – Derivation of bending equation: M/I= f/y = E/R	CO 3	T1:7.2, 7.3, 7.4 R1: 10.2 to 10.5
28	Assumptions – Derivation of bending equation: M/I= f/y = E/R	CO 3	T1:7.2, 7.3, 7.4 R1: 10.2 to 10.5
29	Neutral axis – Determination of bending stresses.	CO 3	T1:7.5 R1: 10.6
30	Section modulus of rectangular (Solid and Hollow) sections.	CO 3	T1:7.7, 7.8 R1: 10.7
31	Section modulus of circular sections (Solid and Hollow) sections.	CO 3	T1:7.7, 7.8 R1: 10.7
32	Section modulus of I,T, Angle and Channel sections	CO 3	T1:7.7, 7.8 R1: 10.7
33	Derivation of formula for shear stress	CO 4	T1:8.1 to 8.3 R1: 11.3 to 11.6
34	Distribution of Shear stress across various beam sections like rectangular, circular, triangular sections.	CO 4	T1:8.1 to 8.3 R1: 11.3 to 11.6
35	Distribution of Shear stress across various beam sections like I, T and angle sections.	CO 4	T1:8.1 to 8.3 R1: 11.3 to 11.6

36	Double integration method for finding the slopes and deflection for different types of beams under different loading conditions.	CO 5	T1:8.1 to 8.3 R1: 11.3 to 11.6
37	Macaulay's method for finding the slopes and deflection for different types of beams under different loading conditions.	CO 5	T1:8.1 to 8.3 R1: 11.3 to 11.6
38	Introduction to theory of pure torsion and assumptions made in pure torsion – Derivation of torsion equation.	CO 6	T1:16.2 R1: 21.2 to 21.4
39	Derivation of torsion equation.	CO 6	T1:16.2 R1: 21.2 to 21.4
40	Torsional moment and polar section modulus.	CO 6	T1:16.3 R1: 21.5, 21.6
41	Torsional moment and polar section modulus. Derive equation for power transmitted by shafts and its efficiency.	CO 6	T1:16.3 R1: 21.5, 21.6
42	Principal stresses and strains- Stresses induced due to uniaxial stress-Stresses induced due to state of simple/pure shear.	CO 6	T1:4.1, 4.2 R1: 4.7
43	Stresses due to biaxial stresses - Stresses due to biaxial stresses along with shear stress.	CO 6	R1: 4.2, 4.3
44	Construction of Mohr's circle for computing the stresses.	CO 6	R1: 4.7
	PROBLEM SOLVING/ CASE STUDIES		
1	A tensile test was conducted on a mild steel bar. The following data was obtained from the test: Diameter of steel bar = 3 cm ; Gauge length of the bar = 20 cm; Load at elastic limit = 250 kN; Extension at load of 150 kN = 0.21 mm; Maximum load = 380kN; Total extension = 60 mm; Diameter of rod at failure = 2.25 cm; Determine: (a) Young's modulus (b) stress at elastic limit (c)percentage elongation (d)percentage decrease in area	CO 1	R2:2.5
2	A steel rod of 3cm diameter and 5m long is connected to two grips and the rod is maintained at a temperature of 95°C. Determine the stress and pull exerted when the temperature falls to 30°C, if (i) the ends do not yield, and (ii) the ends yield by 0.12cm. Take E=2x10^5 MN/m^2 and α = 12x10^{-6}/°C	CO 1	R2:2.8
3	Determine the Poisson's ratio and bulk modulus of a material, for which Young's modulus is 1.2x10^5 N/mm^2 and modulus of rigidity is 4.5x10^4 N/mm^2	CO 1	R2:2.15
4	Analyse the cantilever beam of length 4m carries point loads of 1kN, 2kN and 3kN at 1, 2 and 4m from the fixed end. Draw the S.F and B.M diagrams for the cantilever.	CO 2	R2:4.1

5	Analyse the beam of length 10m is simply supported and carries point loads of 5kN each at a distance of 3m and 7m from the left end and also a uniformly distributed load of 1kN/m between the point loads. Draw the S.F and B.M diagrams for the beam.	CO 2	R2:4.2
6	Analyse the simply supported beam of length 10 m is carrying a uniformly distributed load of 2kN/m for 4m from the right end. Draw the S.F and B.M diagrams for the beam.	CO 2	R2:4.13
7	A square beam 20mm x 20mm in section and 2m long is supported at the ends. The beam fails when a point load of 400N is applied at the centre of the beam. What uniformly distributed load per meter length will break a cantilever of same material 40mm wide, 60mm deep and 3m long?	CO 3	R2:5.5
8	A circular log of wood is used as a beam. If the diameter of the log is 200 mm, find the moment of resistance of the section. Permissible stresses are 10 N/mm^2 in tension and 18 N/mm^2 in compression.	CO 3	R2:5.12
9	The maximum shear stress in a beam of circular section of diameter 150mm is 5.28 N/mm^2. Find the shear force to which the beam is subjected.	CO 4	R2:6.10
10	A steel cantilever beam of 6m long carries 2 point loads 15KN at the free end and 25KN at the distance of 2.5m from the free end. To determine the slope at free end & also deflection at free end $I = 1.3 * 10^8 mm^4$. $E = 2 * 10^5 N/mm^2$	CO 5	R2:7.3
11	A beam having uniform section is 14m long and simple supported at its end and caries a point load of 12KN and 8KN at two points 3m and 4m from the two ends respectively. Take $I = 160 * 10^3 mm^4$ and E=210KN/mm^4 and calculate deflection of the beam at point under the two loads by using macaulays method.	CO 5	R2:7.5
12	A cantilever 2m long is of rectangular section 100mm wide and 200mm deep. it carries a UDL of 2KN/m length for a length of 1.25m from fixed end a point load of 0.8KN at its free end. Find the deflection at the free end. Take E=10GN/m^2	CO 5	R2:7.9
13	A hollow circular shaft, of outside diameter 50 mm and inside diameter 36mm, is made of steel, for which the permissible stress in shear is 90 MPa and G = 85 GPa. Find the maximum torque that such a shaft can carry and the angle of twist per metre length.	CO 6	R2:9.11
14	At a point in a strained material, the principal stresses are 140 N/mm^2 (tensile) and 60N/mm^2 (compressive). Identify the resultant stress in magnitude and direction on a plane inclined at 45^0 to the axis of the major principal stress. What is the maximum intensity of shear stress in the material at the point?	CO 6	R2:9.15

15	A piece of material is subjected to tensile stresses of 70N/ mm^2 and 50N/mm^2 at right angles to each other. Identify the stresses on a plane the normal of which makes an angle 35^0 with the 70N/ mm^2 stress.	CO 6	R2:9.17
	DISCUSSION OF DEFINITION AND TERMINOLOGY		
1	Definitions of stress, strain, elastic modulis, poissons ratio, factor of safety, working stress, ultimate stress and statement of Hooks law	CO 1	R4:2.1
2	Definitions of shear force, bending moment, and types of beams and loads	CO 2	R5:3.6
3	Definition of simple bending, assumptions, equation of bending moment, pure bending and shear stress.	CO 3, CO 4	R6:4.5
4	Definition of shear stress, equation of shear stress, section modulus and radius of gyration	CO 5	R7:2.5
5	Definition of plane stress, strain conditions, types of failures, torsion, angle of twist, torsional equation and rigidity modulus	CO 6	R8:2.6
	DISCUSSION OF QUESTION BANK		
1	Module I	CO 1	R4:2.1
2	Module II	CO 2	T4:7.3
3	Module III	CO 3, CO 4	R4:5.1
4	Module IV	CO 5	T1:7.5
5	Module V	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,AE**
Mr. S Devaraj, Assistant Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**AEROSPACE STRUCTURES LABORATORY**				
Course Code	AAEB11				
Program	B.Tech				
Semester	IV	AE			
Course Type	Elective				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Shravani Madhurakavi, Assistant Professor				

I COURSE OVERVIEW:

The major emphasis of this course is to analyze the behavior of aircraft structural elements subject to various loads trough experiments and observations. The aircraft encounters various loads from take-off to landing which causes loads on its structural parts. These loads include torsions, bending, buckling and shear which are replicated in a laboratory to calculate deflection, buckling, twist and center of twist. A part from this quality inspection test to detect flaws using ultrasonic waves, magnetic particle test are included which also severs the demand of non aerospace industries. .

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS007	I	Applied Physics
B.Tech	AME002	II	Engineering Mechanics
B.Tech	AAE101	III	Mechanics of Solids

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Rocket and Missiles	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	The basic knowledge on the mechanical behavior of materials such as aluminum, mild steel, and cast iron for determining its behavior under different load conditions .

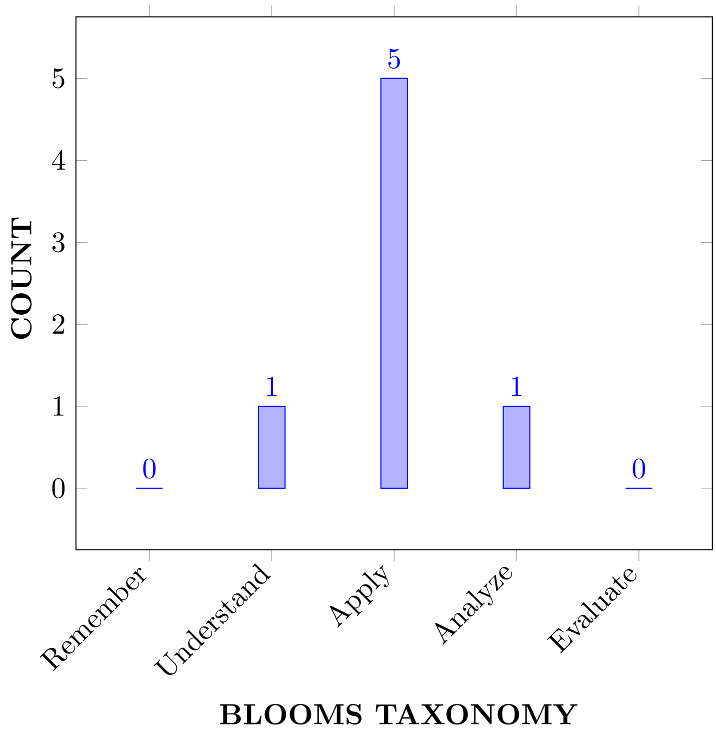
II	The identification of crack/flaws using Non Destructive Testing (NDT) methods for choosing proper materials in engineering applications .
III	Understand the concept of shear centre for open and Closed section of beams for avoiding torsion.
IV	Obtain buckling strength of both long and short columns using different elastic suppsorts .

VII COURSE OUTCOMES:

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

CO 1	**Demonstrate** the properties of materials subjected to tensile loads using the magnitude of stress and strain for engineering applications. .	Understand
CO 2	**Demonstrate** the deflections of beams subjected to transverse loads under various end conditions for aerospace structural design.	Understand
CO 3	**Apply** the Maxwell's reciprocal theorem by using Beam test rig simplifying the analysis through symmetry.	Apply
CO 4	**Illustrate** the critical buckling loads of columns subjected to Compression loads for efficient design of structures under various end conditions.	Understand
CO 5	**Identify** south well's plot for columns subjected to axial loads for identifying critical loads.	Apply
CO 6	**Explain** the Unsymmetrical Bending behavior of a Beam for designing of aerospace structures.	Understand
CO 7	**Infer** the Shear Centre behavior of an open and closed Section beams for avoiding mode of coupling under torsion.	Understand
CO 8	**Explain** the Wagner beam concept for Tension field beam used in aircraft construction for identifying shear flows.	Understand
CO 9	**Explain** the effect of young's modulus of a sandwich for minimizing the weight of an aircraft.	Understand
CO 10	**Explain** the Study of non-destructive testing for detection of flaws in engineering materials.	Understand
CO 11	**Demonstrate** the natural frequency of beams under free and forced vibration for efficient design of structures by minimizing fatigue failure.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIA
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program	Strength	Proficiency Assessed by

PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Utilize the concept of Engineering matrials to a considerable extent appreciate (understanding) their importance and applicability (apply) in solving (complex) structural engineering problems by applying the **principles of Mathematics and Engineering**	3
	PO 2	Understand the (given **problem statement**) and material properties for (provided **information and data**) in reaching substantiated conclusions by the interpretation of results	3
	PSO 3	Apply (**knowledge**) properties of various types matrials and stress-strain curves (apply) for solving design problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 2	PO 1	Explain (understanding) various effects of viscosity in flow through pipes and apply Newtons law of viscosity, in calculating energy loss by applying **principles of Mathematics, Science and Engineering**	3
	PO 5	Understand the (given **problem statement**) effects of viscosity, and capillary rise for the bodies immersed in fluids. (from the provided **information**) in solving analysis problems.	2
	PSO 3	Apply (**knowledge**) Newtons law of viscosity (understanding) in body, under different inlet conditions in (apply) solving flow through pipes by applying the principles of **Mathematics, Science and Engineering**	3
CO 3	PO 1	Summarize (**knowledge**) the concept of pressure measuring devices applications and effect of buoyancy on submerged bodies (understanding) their importance and applicability (apply) in solving (complex) fluid flow engineering problems by applying the textbfprinciples of Mathematics, Science and Engineering	3
	PO 3	Understand the given **problem statement** and formulate (complex) of pressure measuring devices applications and effect of buoyancy on submerged bodies (understanding) their importance and applicability (apply) in solving (**complex**) fluid flow engineering problems from the provided information and substantiate with the **interpretation** of variations in the **results**.	3

	PSO 3	Apply (knowledge) various effects of viscosity, static pressure, surface tension, Newton's law of viscosity, pressure difference and capillary rise (apply) in solving aircraft analysis problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 4	PO 1	Recognize (knowledge) the importance and application (apply) of dimensions, units and dimensional homogeneity in solving (complex) engineering problems with specific emphasis to fluid mechanics by applying the **principles of Mathematics, Science and Engineering**	3
	PO 5	Understand the given **problem statement and formulate** the dimensional analysis and similarity parameters for predicting physical parameters that govern fluid systems in designing prototypes devices	2
	PSO 3	Apply (knowledge) concept of dimensional analysis and similarity parameters for predicting physical parameters (understanding) for the fluid flow analysis used in designing prototypes devices (apply) solving design problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 5	PO 1	Apply the basic conservation laws of science for various phenomena of fluid systems and use **mathematical principles** for deriving (complex) fluid flow engineering equations by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals** of fluid mechanics.	3
	PO 3	Understand the given **problem statement** and formulate (complex) fluid flow engineering phenomena and system for deriving various governing equations of fluid mechanics from the provided information and substantiate with the **interpretation** of variations in the results.	2
	PO 5	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of fluid mechanics.	2
	PSO 3	Apply (knowledge) concept of dimensional analysis and similarity parameters for predicting physical parameters (understanding) for the fluid flow analysis used in designing prototypes devices (apply) solving design problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 6	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** principles to understand the Bernoulli Equation for real flows and its applications	2
	PO 3	Using Euler equation of motion derive the Bernoulli equation to analyze complex fluid flow problems using **principles of mathematics and engineering sciences.**	3

CO 7	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** for determining unit indicators, and performance of hydraulic machines such as speed, discharge and power numbers etc for designing the new equipment's as per the requirements	2
	PO 5	Using first **principles of Sciences and Engineering fundamentals** understand the concept of unit indicators, and performance of hydraulic machines such as speed, discharge and power numbers for designing desired equipment's.	2
	PSO 3	Extend the focus to **understand the innovative and dynamic challenges** involves in evaluation of hydraulic machine performance.	1

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

COURSE OUTCOMES	PROGRAM OUTCOMES			PSO'S
	PO 1	PO 3	PO 5	PSO 3
CO 1	2	3		3
CO 2	2		2	3
CO 3	2	3		3
CO 4	2		2	3
CO 5	2	3	2	3
CO 6	2	3		
CO 7	2		2	3

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**DIRECT TENSION TEST**
	Tensile testing using UTM, mechanical and optical extensometers,stress strain curves and strength test or various engineering materials.
WEEK II	**DEFLECTION TEST**
	Stress and deflections of beams for various end conditions, verification of Maxwell's theorem.
WEEK III	**BUCKLING TEST**
	Compression tests on long columns, Critical buckling loads.
WEEK IV	**BUCKLING TEST**
	Compression tests on short columns, Critical bucklingloads, southwell plot.
WEEK V	**BENDING TEST**
	Shear Centre of an Open Section beam
WEEK VI	**SHEAR CENTRE FOR OPEN SECTION**
	Shear Centre of a Closed Section beam.
WEEK VII	**SHEAR CENTRE FOR ClOSED SECTION**
	Shear Centre of a Closed Section beam.
WEEK VIII	**WAGNER'S THEOREM**
	Wagner beam–Tension field beam.
WEEK IX	**SANDWICH PANEL TENSION TEST**
	Fabrication and determine the young's modulus of a sandwich structures.
WEEK X	**NON-DESTRUCTIVETE TING**
	Study of non-destructive testing procedures using dye penetration.
WEEK XI	**NON-DESTRUCTIVE TESTING**
	Magnetic particle inspection and ultra sonic techniques.
WEEK XII	**VIBRATION TEST**
	Determination of natural frequency of beams under free and forced vibrationusing..

TEXT BOOKS

1. R.K Bansal,—Strength of Materials‖,Laxmi publications, 5th Edition,2012.
2. T. H. G. Megson, —Aircraft Structures for Engineering Students‖, Butterworth-Heinemann Ltd,5th Edition, 2012
3. Gere,Timoshenko,—Mechanics of Materials‖,McGraw Hill,3rd Edition,1993

REFERENCE BOOKS:

1. Peery,D.J.andAzar,J.J.,Aircraft Structures, 2nd edn, McGra-Hill,1982,ISBN0-07-049196-8
2. Bruhn.E.H, Analysis and Design of Flight Vehicles Structures, Tri-state Off-set Company, USA,1965
3. Lakshmi Narasaiah, G.,Aircraft Structures, BS Publications,2010

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Determination of stress-strain curves and strength test of various engineering materials by using tensile testing Machine .	CO 1	T1:1.8
2	verification of Maxwell's theorem by finding Stress and deflections of beams for various end conditions .	CO 2	T1:2.5
3	Determination of Critical buckling loads by Compression tests on long columns .	CO 3	T1:2.9
4	Determination of Critical buckling loads, Southwell plot by Compression tests on short columns. .	CO 4	T1:3.2
5	Determine unsymmetrical Bending of a Beam .	CO 5	T1:3.7
6	Determination of Shear Centre of an Open Section beam .	CO 6	T1:5.3
7	Determination of Shear Centre of a Closed Section beam. .	CO 6	T1:4.5
8	Wagnerbeam–Tension field beam. .	CO 6	T2:3.5 R1:6.8
9	Fabrication and determination of young's modulus of a sandwich structures.	CO 6	T2:7.4 R1:7.1
10	Study of non-destructive testing procedures using dye penetration .	CO 7	T1:12.3 R2:3.2
11	Magnetic particle inspection and ultrasonic techniques.	CO 7	T3:12.10 R1:13.7
12	Determination of natural frequency of beams under free and forced vibration.	CO 7	T3:11.2 R1:10.2

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Tension feild beams:** DWagner beam–Tension field beam.
2	**Vibration test:** Determination of natural frequency of beams under free and forced vibration.

Signature of Course Coordinator **HOD,AE**
Shravani Madhurakavi,
Assistant Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**AERODYNAMICS AND PROPULSIONLABORATORY**				
Course Code	AAEB12				
Program	B.Tech				
Semester	IV	AE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Mr. S. Srikrishnan, Assistant Professor				

I COURSE OVERVIEW:

The course is intended to provide the basic understanding of flow around different aerofoil sections to calculate lift, drag, and moments by using low speed wind tunnel. Propulsion lab deals to understand the performance and efficiency of different compressors, nozzles, propeller and turbines.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB08	IV	Aerospace Propulsion
B.Tech	AAEB03	IV	Aerodynamics

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Aerodynamics and Propulsion Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

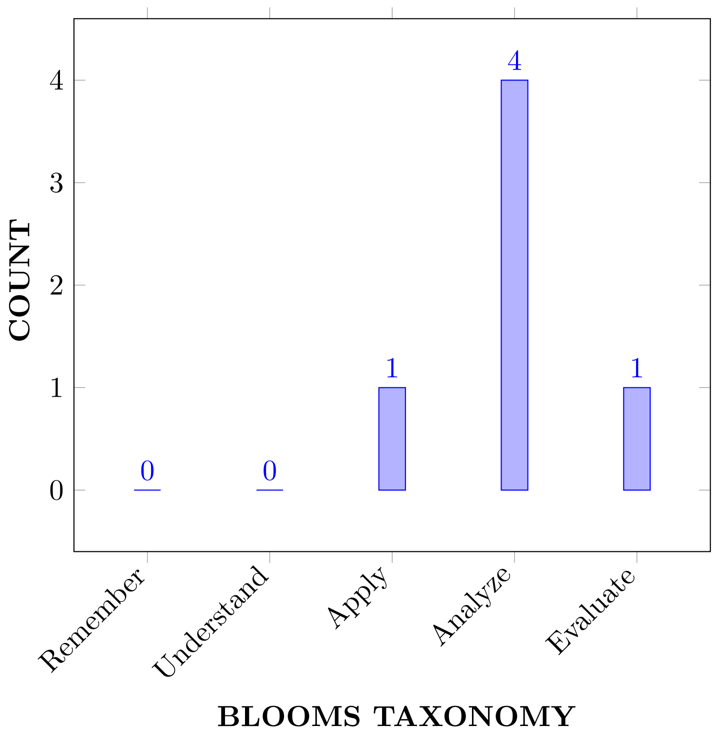
I	To understand the behaviour of flow properties over different models using subsonic wind tunnel.
II	To demonstrate experimentally the pressure distribution over circular, symmetric and cambered aerofoils and evaluate lift and drag.
III	To illustrate flow visualization studies at low speeds over different aerodynamic bodies.
IV	To demonstrate the performance of blower, turbines, nozzles and propellers.
V	To understand the thermodynamic behaviour of gas turbine engines and to calculate different performance parameters.

VII COURSE OUTCOMES:

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

CO 1	**Demonstrate** the wind tunnel calibration for different speeds and velocity and verify by using Pitot Tube of Wind tunnel.	Analyze
CO 2	**Analyze** the pressure distribution of cylinder, symmetrical, and cambered aerofoils at different angles of attack and flow speed by using subsonic wind tunnel.	Analyze
CO 3	**Estimate** the aerodynamic forces and moments of the different models for getting aerodynamic characteristics and wake performance.	Evaluate
CO 4	**Classify** different fuels based on calorific value using bomb calorimeter for selecting optimal fuel in solid rocket motors.	Apply
CO 5	**Categorize** the different types blowers, nozzles and propellers for identifying exit systems in various propulsion systems.	Analyze
CO 6	**Analyze** the mechanical efficiency of gas turbine stages for designing futuristic gas turbine engines based on requirements.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises/CIE/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Lab Exercises/CIE/SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	Lab Exercises/CIE/SEE
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Lab Exercises/CIE/SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises/CIE/SEE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Compare the wind tunnel speed**(mathematics)**with the wind tunnel flow and calibrate the system **(engineering disciplines)**problems.	2
	PO 5	Apply the speed equation by using computer so that the comparison of standard value to present value can be done. **(modern tool usage)**	1
	PSO 3	Apply the basics of wind tunnel knowledge in **mathematical** flows for finding simulation data for **engineering** problems using **modern tools** like ANSYS CFX	2
CO 2	PO 1	Apply the knowledge of pressure distribution over the Airfoil and cylindrical shape models **(mathematics)**and validate the results as per standard values. **(engineering disciplines)**	2
	PO 3	Investigate the effect of design variables on aerodynamic performance **(investigate and define a problem and identify constraints)**understand the design requirements **(understand the customer needs)** attempt to deliver basic design**(innovative solution)** of aircraft wing for real-world application considering economic context.	3
	PO 5	Using gas wind tunnel **(modern tool usage)**to complex aircraft airfoil design activities with an understanding of the limitations.	1
	PSO 3	Apply the basics of wind tunnel knowledge in **mathematical** flows for finding simulation data for **engineering** problems using **modern tools** like ANSYS CFX	
CO 3	PO 1	Apply the knowledge to evaluate the the aerodynamic forces and moments of symmetric and cambered airfoils **(mathematics)** by using 6- Components balance in the Wind tunnel flow. **(Engineering disciplines)**	2
	PO 5	Apply the knowledge gained during theory to evaluate forces and moments using computer technique **(Modern tool usage)**	1
CO 4	PO 1	Apply the knowledge gained to interpret the flow field results of airfoils, flat plate and cylinder considering different aerodynamic laws of flow **(mathematics)**by using wind tunnel and accessories**(engineering discipline).**	2
	PO 5	Using gas wind tunnel **(modern tool usage)**to complex aircraft airfoil design activities with an understanding of the limitations.	1

CO 5	PO 1	Apply the knowledge gained to compare the efficiency of blower **(mathematics)**by changing three types of vanes in an axial flow compressor **(engineering discipline).**	2
	PO 5	Apply momentum equation **(appropriate techniques)**and modern engineering equipment to assess the blower efficiency which can be used as the axial flow systems un aircraft.	1
CO 6	PO 1	Apply the knowledge of momentum loss equation **(mathematics)**to analyze the wake behaviour and its effects on drag of the airfoils / Aircraft model using wake rack in a wind tunnel flow **Engineering discipline).**	2
	PO 5	Use the wake rack system **(appropriate technique)**to measure the drag of the airfoil or aircraft model using wind tunnel flow system.	1

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

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

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1, PO 3, PSO 3	SEE Exams	PO 1,PO 3,PO5, PSO 3	Seminars	-
Laboratory Practices	PO 1,PO 3,PO 5, PSO 3	Student Viva	PO 1, PO 5,	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**CALIBRATION AND PRESSURE DISTRIBUTION-CYLINDER**
	Calibration of subsonic wind tunnel, Pressure distribution over cylinder.
WEEK II	**PRESSURE DISTRIBUTION AND FLOW VISUALIZATION -SYMMETRIC, CAMBERED AIRFOIL**
	Pressure distribution and flow visualization over symmetric, cambered airfoil.
WEEK III	**FORCE MEASUREMENT**
	Force measurement using wind tunnel balance.
WEEK IV	**WAKE ANALYSIS**
	Wake analysis over a cylinder and airfoils.
WEEK V	**FLOW OVER A FLAT PLATE**
	Flow over a flat plate.
WEEK VI	**BLOWER TEST RIG**
	Efficiency of blower test rig for 3 different vane settings.
WEEK VII	**GAS TURBINE PARAMETERS CALCULATION**
	Calculation of thrust requirement in gas turbine.
WEEK VIII	**GAS TURBINE EFFICIENCY AND PERFORMANCE DIAGRAMS**
	Elucidate T-S, H-S diagrams for the gas turbine and compare efficiencies of non-ideal engine components.
WEEK IX	**GAS TURBINE EFFICIENCY CALCULATIONS**
	Calculation efficiencies of individual components of a gas turbine cycle.
WEEK X	**NOZZLE PERFORMANCE**
	Estimating the performance of nozzle under different airflow conditions
WEEK XI	**CALORIFIC VALUE OF DIFFERENT FUELS**
	Calculation of calorific value of different fuels using digital bomb calorimeter.
WEEK XII	**PROPELLER TEST RIG**
	Calculation of propeller efficiency and thrust availability using propeller test rig at various blade pitch angles.

Reference Books:

1. L. J. Clancy, "Aerodynamics", Pitman, 1st Edition, 1986.
2. 2. Alan pope, "Low Speed Wind Tunnel Testing", John Wiley, 2nd Edition, 1999.
3. Jack D. Mattingly, "Elements of Gas Turbine Propulsion", McGraw-Hill, 1995.
4. H.I.H. Saravanamuttoo, "Gas TurbineTheory", Pearson, 7th Edition, 2017.
5. N. M. Komerath, "Low Speed Aerodynamics", Extrovert, 1st Edition, 2012.
6. Ahmed F. El-Sayed , "Aircraft Propulsion and Gas Turbine Engines", CRC Press, 2017.

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Calibration of subsonic wind tunnel, Pressure distribution over cylinder	CO 1	R1: 2.2
2	Pressure disRribution and flow visualization over symmetric, cambered airfoil.	CO 2	R1: 3.2
3	Force measurement using wind tunnel balance.	CO 3	R2: 2.4
4	Wake analysis over a cylinder and airfoils.	CO 2	R1: 2.6
5	Flow over a flat plate	CO 3	R4: 2.5
6	Efficiency of blower test rig for 3 different vane settings.	CO 5	R2: 5.4
7	Gas turbine parameters calculationl.	CO 6	R3: 4.2
8	Gas turbine efficiency and performance diagrams.	CO 6	R3: 5.7
9	Gas turbine efficiency calculations.	CO 6	R3: 5.7
10	Nozzle performance.	CO 5	R4: 3.2
11	Calorific value of different fuels.	CO 4	R6: 5.2
12	Propeller test rig.	CO 5	R3: 5.6

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Shear stress distribution using over aerodynamic surface using oil flow visualization.
2	Aerodynamic characteristics of modified aerofoil using ANSYS CFX.
3	Simulation of wing tip vortices on a finite wing with winglets .
4	Cascade testing of axial flow compressor using ANSYS CFX.
5	Cascade testing of axial flow turbine using ANSYS CFX.
6	Separation control in gas turbine intake using ANSYS CFX.

Signature of Course Coordinator **HOD,AE**
Mr. S. Srikrishnan, Assistant Professor

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**AEROSPACE PROPULSION**				
Course Code	AAEB08				
Program	B.Tech				
Semester	FOUR				
Course Type	Core				
Regulation	R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Dr.Praveen Kumar Balguri				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB02	III	Engineering Thermodynamics
B.Tech	AAEB03	III	Fluid Dynamics

II COURSE OVERVIEW:

An Aerospace Propulsion system is a machine that produces thrust to push an aircraft forward. This course introduces various aircraft propulsion systems, and their performance analysis. The course discusses the operating principles of the aircraft engine's major components such as inlets, compressors, turbines, and nozzles. The design parameters, performance characteristics, and the factors influencing them are also addressed. This courseis a prerequisite to the next level course, Turbomachinery.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Aerospace Propulsion	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

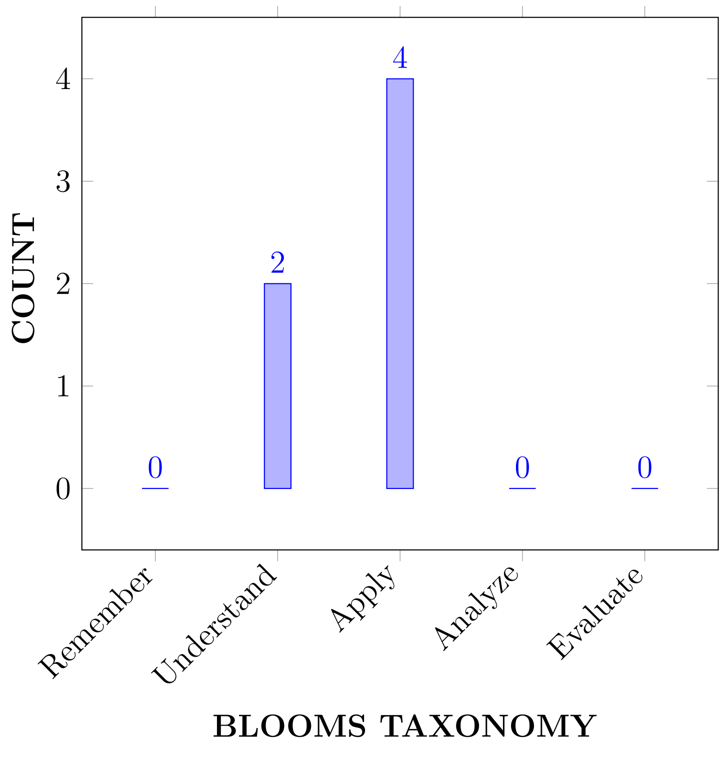
I	The fundamentals of air-breathing propulsion system, their operating principles, and function of an individual component.
II	The geometry of flow inlets, combustion chambers, and factors affecting their performance.
III	The establishment of flow through various inlets and nozzles under different operating conditions.
IV	The operating principles of various compressors, turbines and performance characteristics under different flight conditions.

VII COURSE OUTCOMES:

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

CO 1	**Compare** the operating principles of various gas turbine engines and their components for selecting the suitable engine as per the mission requirements.	Understand
CO 2	**Utilize** the thrust equation and engine cycle analysis for achieving the required performance.	Apply
CO 3	**Apply** the knowledge of flow through various inlets, and nozzles under various operating conditions for selecting the suitable inlets and nozzle as per the mission requirement.	Apply
CO 4	**Compare** the different types of combustion chambers for identifying the design variables affecting their performance.	Understand
CO 5	**Make use of** the performance characteristics and efficiencies of different compressors and turbines for identifying a suitable combination.	Apply
CO 6	**Identify** the important design performance parameters of ramjet engine towards developing optimized ramjet engine.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards	3	Quiz

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recognize the operating principles of each major components and like whole different gas turbines **(scientific principles and own engineering discipline)** to the solution of complex aircraft engine design problems by applying principles of gas turbine engines **(science and own and/or other engineering disciplines knowledge)**.	2
CO 2	PO 1	Apply the knowledge of parameters **(scientific principles)** that determine the cycle efficiency and the performance of aircraft propulsion systems to the solution of complex aircraft engine problems **(own engineering discipline)**.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Identify the required performance characteristics of the engine **(problem identification)**, define the required engine performance parameters **(problem statement and system definition)** using the knowledge of various gas turbines engine cycle analysis **(information and data collection/review of literature)**, develop the major performance characteristics of gas turbines **(design, and reaching the substantial solution)** as per the mission requirements.	5
CO 3	PO 1	AApply the knowledge of the flow pattern in inlets and nozzles **(scientific principles and mathematical principles)** to the solution of complex engineering problems.	2
	PO 2	Identify the problems **(Identify)**of flow pattern in inlets,nozzles review research literature **(information and data collection)**, and analyze complex engineering problems, design**(design)** reaching suitable inlet and nozzle **(solution)**.	4
	PO 4	Use the knowledge of different problems of flow in inlets, nozzles **(knowledge of characteristics of particular processes)** in selecting the suitable inlet, and nozzle **(understanding of contexts in which engineering knowledge can be applied)**.	2
CO 4	PO 1	Apply the knowledge of different types of combustion chambers **(principles of mathematics and own engineering discipline)** to select a suitable combustion chamber as per the given mission requirement.	2
	PO 2	Define the mission requirement **(problem statement and system definition)** and apply the knowledge of different types of combustion chambers available **(information and data collection)** for aircraft engines to select the suitable one **(solution development)** during the conceptual phase.	3
CO 5	PO 1	Apply the knowledge of different compressors and turbines **(mathematical and engineering principles)** during the selection of a suitable power plant for the given role requirement.	2
	PO 4	Use the knowledge of performance characteristics and efficiency of different compressors and turbines **(knowledge of characteristics of particular products)** in selecting the suitable power-plant **(understanding of contexts in which engineering knowledge can be applied, understanding use of technical literature and other information sources)**.	3
	PSO 1	**Synthesize and analyze** different compressors and turbines in aeronautical systems to provide the power plant **(propulsion)** for the aircraft.	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	PO 1	Apply the knowledge of important design performance parameters under different operating conditions **(mathematical principles, own engineering disciplines)** during the conceptual design of ramjet propulsion systems.	2
	PO 2	Identify the problems **(Identify)** of high speed aircraft design, review research literature **(information and data collection)**, and analyze complex engineering problems, design**(design)** reaching suitable conceptual design of ramjet **(solution)**.	4

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.7	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.7	40	-	20	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.7	30	-	-		-	-	-	-	-	-		-	-	-
CO 5	66.7	30	-	36.3	-	-	-	-	-	-	-	-	100	-	-
CO 6	66.7	40	-	-		-	-	-	-	-	-		-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	1	-	1	-	-	-	-	-	-	-	-	3	-	-
CO 6	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	6	-	2	-	-	-	-	-	-	-	-	3	-	-
AVERAGE	3	1.2	-	1	-	-	-	-	-	-	-	-	3	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**AIR-BREATHING ENGINES**
	Classification, operational envelopes; Description and function of gas generator, turbojet, turbofan, turboprop, turbo shaft, ramjet, scramjet, turbojet/ramjet combined cycle engine; Engine thrust, takeoff thrust, installed thrust, thrust equation; Engine performance parameters, specific thrust, specific fuel consumption and specific impulse, thermal efficiency, propulsive efficiency, engine overall efficiency and its impact on aircraft range and endurance; Engine cycle analysis and performance analysis for turbojet, turbojet with afterburner, turbofan engine, turboprop engine.
MODULE II	**INLETS AND COMBUSTION CHAMBERS**
	Internal flow and stall in subsonic inlets, relation between minimum area ratio and eternal deceleration ratio, diffuser performance, supersonic inlets, starting problem on supersonic inlets, shock swallowing by area variation; Classification of combustion chambers, combustion chamber performance, effect of operating variables on performance, flame stabilization.
MODULE III	**NOZZLES**
	Theory of flow in isentropic nozzles, nozzles and choking, nozzle throat conditions, nozzle efficiency, losses in nozzles. Over expanded and under expanded nozzles, ejector and variable area nozzles, interaction of nozzle flow with adjacent surfaces, thrust reversal.

MODULE IV	**COMPRESSORS**
	Principle of operation of centrifugal compressor and axial flow compressor, work done and pressure rise, velocity triangles, degree of reaction, free vortex and constant reaction designs of axial flow compressor, performance characteristics of centrifugal and axial flow compressors, stage efficiency calculations, cascade testing.
MODULE V	**TURBINES**
	Principle of operation of axial flow turbines, limitations of radial flow turbines, work done and pressure rise, velocity triangles, degree of reaction, free vortex and constant angle designs, performance characteristics, sample ramjet design calculations, flame stability problems in ramjet combustors, integral ram rockets.

TEXTBOOKS

1. Hill, P.G. and Peterson, C.R. "Mechanics and Thermodynamics of Propulsion" ,Addison Wesley Longman INC, 1999.
2. Mattingly J.D., "Elements of Propulsion: Gas Turbines and Rocket", AIAA, 1991.

REFERENCE BOOKS:

1. Cohen, H.Rogers, G.F.C. and Saravanamuttoo, H.I.H,"Gas Turbine Theory", Longman, 1989.
2. Oates, G.C., "Aero thermodynamics of Aircraft Engine Components", AIAA Education Series, New York, 1985.

WEB REFERENCES:

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

COURSE WEB PAGE:

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
0	Course OBE Discussion		
CONTENT DELIVERY (THEORY)			
1	Introduction to aerospace propulsion- Components of gas turbine engine	CO 1	T2-1.1 , 1.3, 1.4, 1.7
2	Classification of jet engines-Turbojet	CO 2	T1-1.2,1.8,1.9
3	Turbofan engines	CO 2	T2- 1.15, 1.16
4	Turboprop and turboshaft engines	CO 2	T2- 1.6
5	Ramjet, scramjet, combined cycle engine	CO 3	T2- 2.2, 2.6

6	Thrust equation for jet engines	CO 3	R1-2.6, 2.10
7	Engine performance parameters	CO 4	T2-3.2, 3.3
8	Ideal cycle analysis of Turbo jet engine	CO 4	T2-3.5
9	Internal flow and stall in subsonic inlets	CO 3	T2-2.13, 2.14and 2.16
10	Operational modes of subsonic inlets	CO 3	R2-2.15
11	Operational modes of supersonic inlets	CO 3	R2-3.9, 3.6
12	Starting problem on supersonic inlets	CO 3	T2-6.1, 6.3
13	Classification of combustion chambersr	CO 5	T1-6.2, 6.3
14	Components of the combustion chamber	CO 5	T2-6.5, 6.6
15	Combustion chamber performance	CO 5	R1-6.7, 6.8
16	Flame stabilization in gas turbine combustion chamber	CO8	T2-7.1
17	Isentropic flow through a convergent nozzle	CO 5	T1- 7.2, 7.3 and 7.4
18	Isentropic flow through convergent-divergent nozzle	CO 5	T2- 7.9
19	Nozzle choking	CO 5	T2-7.9, 7.10
20	Nozzle efficiency and losses in nozzles.	CO 5	T2- 7.11
21	Operating conditions of nozzle	CO 6	T2- 10.1, 10.2, 10.3
22	Variable area nozzles	CO 6	T2-10.4, 10.5
23	Thrust reversal	CO 3	R2-2.15
24	Principle of operation of centrifugal compressor	CO 3	R2-3.9, 3.6
25	Work done and pressure rise across centrifugal compressor	CO 3	T2-6.1, 6.3
26	Principle of operation of axial flow compressor	CO 5	T1-6.2, 6.3
27	Work done and pressure rise across axial flow compressor	CO 5	T2-6.5, 6.6
28	Free vortex and constant reaction designs of axial flow compressor	CO 5	R1-6.7, 6.8
29	Performance characteristics of centrifugal compressor	CO8	T2-7.1
30	Performance characteristics of axial compressor	CO 5	T1- 7.2, 7.3 and 7.4
31	Stage efficiency of axial and centrifugal compressor	CO5	T2- 7.9

32	Cascade testing of compressor blade	CO 5	T2-7.9, 7.10
33	Principle of operation of axial flow turbines	CO 5	T2- 7.11
34	Limitations of radial flow turbines	CO 6	T2- 10.1, 10.2, 10.3
35	Work done and pressure drop across axial turbine	CO 6	T2-10.4, 10.5
36	Free vortex and constant angle designs of axial flow turbine	CO 3	T2-6.1, 6.3
37	Performance characteristics of axial flow turbine	CO 5	T1-6.2, 6.3
38	Turbine blade cooling	CO 5	T2-6.5, 6.6
39	Flame stability problems in ramjet combustors	CO 5	R1-6.7, 6.8
40	Integral ram rockets	CO8	T2-7.1
PROBLEM SOLVING/ CASE STUDIES			
41	Ideal cycle analysis of turbojet	CO 1, CO 2	
42	Performance analysis of gas turbine	CO1, CO 2	
43	Performance analysis of gas turbine	CO 1, CO 2	
44	Ideal cycle analysis of turbofan	CO 1, CO 2	
45	Diffuser performance	CO 3	
46	Diffuser performance	CO 3	
47	Nozzle performance	CO 3	
48	Nozzle operating conditions	CO 3	
49	Axial flow compressor performance	CO 5	
50	Centrifugal compressor performance	CO 5	
51	Multi stage compressor	CO 5	
52	Axial flow turbine performance	CO 5	
53	Compressor Velocity triangles	CO 5, CO 6	
54	Turbine Velocity triangles	CO 5	
55	Ramjet Calculations	CO 6	
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Gas turbines	CO 1, CO 2	
57	Inlets and combustion chamber	CO 3, CO 4	
58	Nozzle flow	CO 3	
59	Compressor	CO 5	
60	Turbine, Ramjet	CO 5, CO 6	

DISCUSSION OF QUESTION BANK			
61	Air-Breathing Engines	CO 1, CO 2	
62	Inlets and Combustion Chambers	CO 3	
63	Nozzles	CO 4, CO 5	
64	Compressors	CO 5	
65	Turbines	CO 5, CO 6	

Signature of Course Coordinator **HOD**

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

COURSE DESCRIPTION

Department	Aeronautical Engineering				
Course Title	Flight Mechanics				
Course Code	AAEB09				
Program	B.Tech				
Semester	IV				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr V Raghavender, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEC03	III	Fluid Dynamics

II COURSE OVERVIEW:

Flight mechanics is the science that investigates the performance of the aircraft as applied to flight vehicles and to provide a clear understanding of related topics, specifically on aerodynamics, propulsion,performance, stability and flight controls. The course introduces the fundamental principles of aerodynamics and propulsion for aircraft performance in classical flying stages. This course is the point of confluence of other disciplines with aeronautical engineering and the gateway to aircraft design.

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
33.3%	Understand
50%	Apply
16.6%	Analyze

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

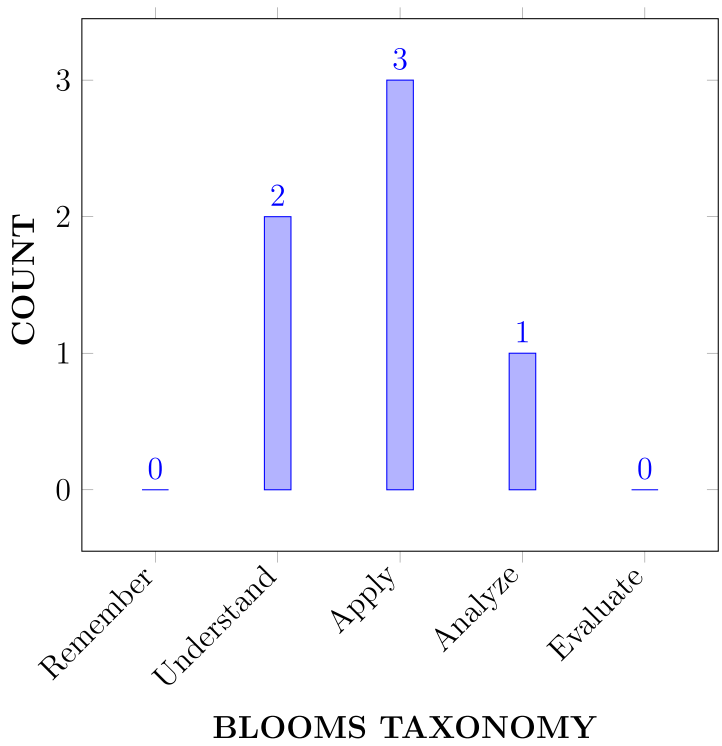
I	The fundamental principles of aerodynamics and propulsion for aircraft performance in classical flying stages.
II	The different regimes of aircraft and performance requirements at various atmospheric conditions.
III	The mathematical models for various types of maneuvers, safety requirements during takeoff, landing for better performance and stability.

VII COURSE OUTCOMES:

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

CO 1	**Demonstrate** the mission profiles of simple cruise, commercial transport and military aircrafts for getting the airplane performance characteristics	Understand
CO 2	**Explain** the cruise performance of an airplane in relation with range and endurance with different types of aircraft engines.	Understand
CO 3	**Identify** the effects of constant angle of attack, constant mach number, and constant altitude in cruise performance for notifying the minimum, maximum speeds in flight	Apply
CO 4	**Apply** the concept of climb, descent performance along with energy height, specific excess power and energy methods for achieving optimal flight conditions.	Apply
CO 5	**Develop** the aircraft manoeuvre performance to perform in turn, pull-up and pull down manoeuvres by considering limitations of power for military and civil aircrafts.	Apply
CO 6	**Compare** the various landing distances such as discontinued landing, baulk landing for better stability and control of the aircraft.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards	3	Quiz
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	1	Quiz

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Apply the knowledge of mathematics to understand the basics of aircraft performance, determining reactions and resultants of forces using the using principles of mathematics, science, and engineering fundamentals.	2
CO 2	PO 1	Identity the cruise performance of an airplane in relation with range and endurance with different types of engines also to understand effects of weight, altitude and temperature on performance using principles of mathematics, science, and engineering fundamentals.	3
	PO 5	Develop the concept of climb and descent performance and to calculate power for best climb and descent performance by using appropriate techniques with an understanding of the limitations of Modern Tools.	3
	PO 10	Comprehend and write effective reports that are employed during takeoff and landing phases depending upon its mission by developing good communication.	2
CO 3	PO 1	Recall (knowledge) the definition of aircraft performance for different categories of aircraft by using scientific principles and methodology.	2
	PO 2	Interpret the force system of the aircraft and the development of equations of motion by using first principles of mathematics and engineering sciences.	4
	PSO 2	Make use of experimental tools for innovation to assess aircraft behavior in different stages of aircraft flight to obtain desired knowledge for higher studies.	3
CO 4	PO 1	Identify (knowledge) the performance of aircraft in cruising phase and appropriate conclusions are drawn with the fundamentals of mathematics, science, and engineering fundamentals.	3
	PO 2	Illustrate different methods for the measurement of air data and their respective systems working principle first principles of mathematics and engineering sciences.	4

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 2	Interpret the force system of the aircraft and the development of equations of motion as individual and team work.	2
CO 5	PO 1	Develop the flight measurement of performance, with detailed sections on airworthiness certification and the performance manual with the knowledge of mathematics, science and engineering fundamentals related to aeronautics.	3
	PO 5	Discuss the parametric performance data analysis for different phases of aircraft and various methods of measurement using modern Engineering and IT tools to solve complex stability problem.	4
	PSO 1	Illustrate the performance of aircraft in cruising phase and appropriate conclusions are drawn by communicating effectively to with engineering community.	2
CO 6	PO 1	Develop the mathematical model of equation of motion for accelerated flight by Knowledge and understanding of complex engineering problem using mathematical principles.	2

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	-	-	66.7	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	50	20	66.7	20	-	-	-	-	-	-	-	-	-	50
CO 3	66.7	60	-	-	45.5	-	-	-	-	-	-	40	-	-	18
CO 4	100	-	50	45.5	45.5	-	-	-	-	-	-	40	-	-	-
CO 5	66.7	20	-	18	18.2	-	-	-	-	-	-	40	-	-	50
CO 6	66.7	50	50	45.5	40	-	-	-	-	-	-	18	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	2	1	2	1	-	-	-	-	-	-	-	-	-	2
CO 3	2	2	1	-	2	-	-	-	-	-	-	2	-	-	1
CO 4	2	-	-	3	2	-	-	-	-	-	-	2	-	-	-
CO 5	2	1	1	3	1	-	-	-	-	-	-	2	-	-	2
CO 6	1	2	2	2	2	-	-	-	-	-	-	1	-	2	-
TOTAL	**11**	**7**	**05**	**12**	**8**	**0**	**0**	**0**	**0**	**0**	**0**	**7**	**0**	**3**	**5**
AVERAGE	**1.6**	**1.7**	**1.2**	**2.4**	**1.5**	**0**	**0**	**0**	**0**	**0**	**0**	**1.7**	**0**	**1.5**	**1.6**

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO AIRCRAFT PERFORMANCE**
	The role and design mission of an aircraft; Performance requirements and mission profile; Aircraft design performance, the standard atmosphere; Off-standard and design atmosphere; Measurement of air data; Air data computers; Equations of motion for performance - the aircraft force system; Total airplane drag- estimation, drag reduction methods; The propulsive forces, the thrust production engines, power producing engines, variation of thrust, propulsive power and specific fuel consumption with altitude and flight speed; The minimum drag speed, minimum power speed; Aerodynamic relationships for a parabolic drag polar.
MODULE II	**CRUISE PERFORMANCE**
	Maximum and minimum speeds in level flight; Range and endurance with thrust production, and power producing engines; Cruise techniques: constant angle of attack, constant Mach number; constant altitude, methods-comparison of performance. The effect of weight, altitude and temperature on cruise performance; Cruise performance with mixed power-Plants.
MODULE III	**CLIMB AND DESCENT PERFORMANCE**
	Importance of Climb and descent performance, Climb and descent technique generalized performance analysis for thrust producing, power producing and mixed power plants, maximum climb gradient, and climb rate. Energy height and specific excess power, energy methods for optimal climbs - minimum time, minimum fuel climbs. Measurement of best climb performance. Descent performance in Aircraft operations. Effect of wind on climb and decent performance.
MODULE IV	**AIRCRAFT MANEUVER PERFORMANCE**
	Lateral maneuvers- turn performance- turn rates, turn radius- limiting factors for turning performance. Instantaneous turn and sustained turns, specific excess power, energy turns. Longitudinal aircraft maneuvers, the pull-up, maneuvers. The maneuver envelope, Significance. Maneuver boundaries, Maneuver performance of military Aircraft, transport Aircraft.

MODULE V	**SAFETY REQIREMENTS – TAKEOFF AND LANDING PERFORMANCE AND FLIGHT PLANNING**
	Estimation of takeoff distances. The effect on the takeoff distance of weight wind, runway conditions, ground effect. Takeoff performance safety factors. Estimation of landing distances. The discontinued landing, Baulk landing, air safety procedures and requirements on performance. Fuel planning fuel requirement, trip fuel, Environment effects, reserve, and tankering.

TEXT BOOKS

1. Anderson, J.D. Jr., "Aircraft Performance and Design", International Edition McGraw Hill,1st Edition, 1999 .
2. Eshelby, M.E., "Aircraft Performance theory and Practice", AIAA Education Series, AIAA,2nd Edition, 2000

Reference BOOKS

1. McCormick,B.W,"Aerodynamics,AeronauticsandFlightMechanics",JohnWiley,2ndEdition,1995
2. Yechout,T.R.etal.,"IntroductiontoAircraftFlightMechanics",AIAAEducationSeries,AIAA,1st Edition, 2003, ISBN:1 Shevel, R.S., "Fundamentals of Flight‖, Pearson Education", 2ndEdition, 1989

WEB REFERENCES:

https://akanksha.iare.ac.in/index?route=course/detailscourse$_id = 105$

COURSE WEB PAGE:

https://akanksha.iare.ac.in/index?route=course/detailscourse$_id = 105$

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	https://lms. iare.ac.in / index?route= course/details and courseid=285
CONTENT DELIVERY (THEORY)			
2	The role and design mission of an aircraft	CO	T1: 2.1
3	Performance requirements and mission profile	CO 1	T2:1.1-12 T1:2.1-3
4	The standard atmosphere; Off-standard and design atmosphere; Measurement of air data;	CO 2	T2:1.3-1.5 T1:2.3-4
5	Air data computers	CO 1	T1: 2.12-2.13,21,22
6	Equations of motion for performance -	CO 1	T2:.3.1-3.2
7	The aircraft force System	CO 2	T1:3.1-4 R2:3.3

8	Total airplane drag- estimation, drag reduction methods	CO 4	T1:3.5-7 R2:3.4
9	The thrust production engines, power producing engines	CO 1	T2:3.4 R1: 3.1
10	Variation of thrust, propulsive power	CO 3	T1-6.1 to 6.3
11	Specific fuel consumption with altitude and flight speed	CO 2	T1: 8.1-8.4
12	The minimum drag speed, minimum power speed;	CO 2	T1: 8.5-7.9
13	Maximum and minimum speeds in level flight	CO 2	T1: 7.19-7.22
14	Aerodynamic relationships for a parabolic drag polar	CO 2	T1: 14.1-14.4
15	Cruise techniques: constant angle of attack, constant Mach number; constant altitude, methods	CO 2	T1: 14.5-14.6
16	Comparison of performanc	CO 4	T1: 14.7
CONTENT DELIVERY (THEORY)			
17	The effect of weight, altitude and temperature on cruise Performance	CO 2	T1: 9.1-9.10
17	Cruise performance with mixed power-Plants	CO 4	T1: 10.1-10.6
19	Importance of Climb and descent performance	CO 5	R3: 7.1-7.3
20	Climb and descent technique generalized performance analysis for thrust producing	CO 4	T1: 5.15
21	Power producing and mixed power plants	CO 6	R2-7.3.1 to 7.3.2
22	Maximum climb gradient, and climb rate	CO 6	T1: 21.1-21.2
23	Energy height and specific excess power	CO 5	T1: 21.5b
24	Energy methods for optimal climbs - minimum time, minimum fuel climbs	CO 5	R2:11.1-11.3
25	Measurement of best climb performance and descent performance in Aircraft operations	CO 5	R2:11.4-11.5
26	Lateral maneuvers- turn performance- turn rates, turn radius	CO 4	R4:1.1
27	Limiting factors for turning performance	CO 6	R1:2.7
28	Instantaneous turn and sustained turns	CO 5	R1:2.2
29	Specific excess power	CO 5	R1:3.1
30	Energy turns	CO 3	R1:3.5
31	Longitudinal aircraft maneuvers, the pull-up, maneuvers	CO 5	R1:3.6
32	The maneuver envelope, Significance of maneuver boundaries	CO 6	R1:3.6.1
33	Maneuver performance of military Aircraft, transport Aircraft Estimation of takeoff distances	CO 6	R1:3.6.2
34	The effect on the takeoff distance of weight wind, , Takeoff performance safety factors	CO 6	R4:3.6.3
35	Estimation of landing distances, The discontinued landing, Baulk landing	CO 6	R1:3.14

36	Air safety procedures	CO 5	T1-13.14
37	Fuel planning fuel requirement	CO 5	T1-13.16 to 13.18
38	Trip fuel	CO 4	T1-13.19
39	Environment effects	CO 5	T1-13.19
40	reserve, and tinkering.	CO 6	T1-13.20
41	Air safety requirements on performance	CO 5	T1-13.20
PROBLEM SOLVING/ CASE STUDIES			
42	Problems on standard atmosphere	CO 1	T1: 2.1
43	Problems on Aerodynamic forces	CO 2	T1: 2.2-2.8
44	Problems on Equation of Motion	CO 1	T1: 2.9-2.10
45	Problems on Rate of climb	CO 6	T1: 2.12-2.13,21,22
46	Problems on Range for propeller driven aircrafrt	CO 5	T1: 4.1-4.3
47	Problems on Range for Jet driven aircraft	CO 6	T1: 6.5
48	Problems on Endurance propeller driven aircrafrt	CO 5	T1: 6.6
49	Problems on Endurance Jet driven aircraft	CO 5	T1: 7.1-7.3
50	Problems on drag estimation	CO 5	T1: 2.1
51	Problems on excess power	CO 6	T1: 2.2-2.8
52	Problems on V-N diagram	CO 5	T1: 8.5-7.9
53	Problems on minimum power speed	CO 5	R1:3.1
54	Problems on climb rate	CO 6	R1:3.6.2
55	Problems on energy turns	CO 4	R1:3.6.3
56	Problems on takeoff	CO 4	R2:3.14
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Introduction Airplane Performance	CO 1	T1: 2.2-2.8
58	Cruise Performance	CO 2	T1: 2.9-2.10
59	Climb and Descent Performance	CO 6	T1: 2.12-2.13,21,22
60	Aircraft Maneuver Perfoemance	CO 5	T1: 14.5-14.6
61	Safety Reqirements – Takeoff And Landing Performance And Flight Planning	CO 5	R4:3.6
DISCUSSION OF QUESTION BANK			
62	Introduction Airplane Performance	CO 1	T1: 2.2-2.8
63	Cruise Performance	CO 5	T1: 14.5-14.6
64	Climb and Descent Performance	CO 5	T1: 6.6
65	Aircraft Maneuvore Perfoemance	CO 5	T1: 2.1
66	Safety Reqirements – Takeoff And Landing Performance And Flight Planning	CO 5	R2:3.6.2

Course Coordinator **HOD,AE**
Mr V Raghavender, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

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

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

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

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

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

Signature of Course Coordinator **HOD,**

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**DATA STRUCTURES LABORATORY**				
Course Code	ACSB05				
Program	B.Tech				
Semester	IV	AE			
Course Type	CORE				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Mr. P Ravinder, Assistant Professor, CSE				

I COURSE OVERVIEW:

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

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	ACSB01	I	Programming for problem solving

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
DATA STRUCTURES LABORATORY	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

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

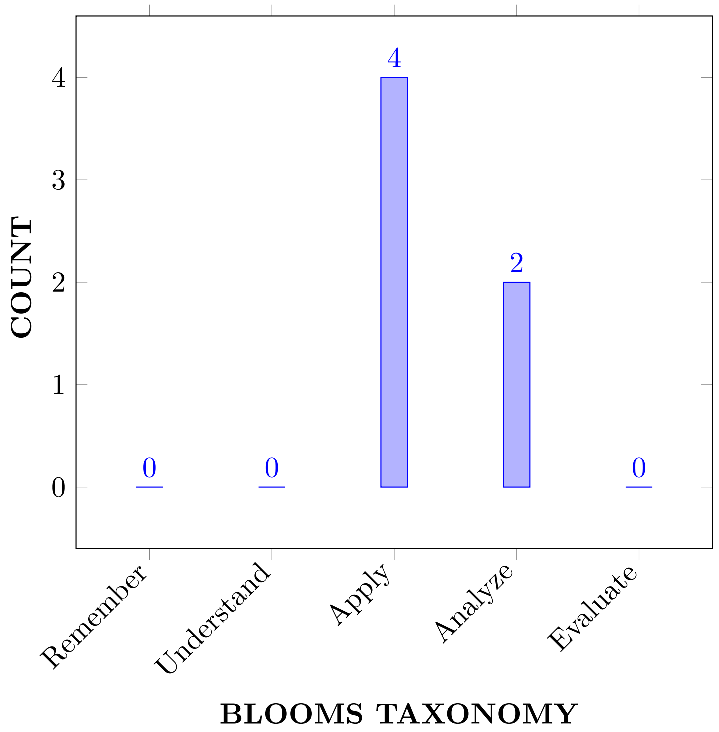
VII COURSE OUTCOMES:

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

CO 1	Carryout the analysis of a range of algorithms in terms of algorithm analysis and express algorithm complexity using the O notation.	Apply
CO 2	Implement techniques like searching, to find the most efficient solutions for underlying problems in different domains.	Apply
CO 3	Gain the knowledge of basic abstract data types (ADT) and associated algorithms for organizing programs into modules using criteria that are based on the data structures of the program.	Understand
CO 4	Interpret the recursive and non-recursive techniques to solve problems in DFS of Graph, Towers of Hanoi, Different Types of Tree Traversals, and others (Graphs and Tree traversals)	Apply
CO 5	Implement the sorting algorithm to order the elements of the array according to zip code before printing a set of mailing labels.	Analyze
CO 6	Apply appropriate data structures for solving computing problems with respect to performance.	Analyze
CO 7	Interpret Dynamic data structures like linked list considered efficient with respect to memory complexity of the code.	Analyze
CO 6	Apply appropriate data structures for solving computing problems with respect to performance.	Analyze
CO 8	Extend their knowledge of data structures to more sophisticated data structures to solve problems involving balanced binary search trees, AVL Trees, B-trees and B+ trees, hashing, and basic graphs.	Analyze
CO 9	Interpret the use of basic data structures such as arrays, stacks, queues and linked lists in program design.	Analyze
CO 10	Interpret the benefits of dynamic and static data structures with respect to memory complexity of the code.	Analyze
CO 11	Apply appropriate data structures for solving computing problems with respect to performance.	Analyze

CO 12	Implement the hashing technique to triad's primary principles of assuring the integrity of data	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

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

PO 5	**Conduct investigations of complex problems:** 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 / / CIA/SEE
PO 10	**Communication:**Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	3	LAB PROGRAMS / / CIA/SEE
PO 12	**Life-long learning:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	LAB PROGRAMS / / CIA/SEE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Understand, design and analyze computer programs in the areas related to Algorithms, System Software, Web design, Big data, Artificial Intelligence, Machine Learning and Networking.	2	LAB PROGRAMS / CIA/SEE

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Understand (knowledge) the basic concept of algorithm analysis which provides theoretical estimates for the resources needed by any algorithm for a given computational problem. These estimates provide an insight into reasonable directions of search for efficient algorithms by applying the principles of mathematics and science.	3
	PO 5	Understand the (knowledge) appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	3
CO 2	PO 1	Understand (knowledge) the basic concept of algorithm analysis which provides theoretical estimates for the resources needed by any algorithm for a given computational problem. These estimates provide an insight into reasonable directions of search for efficient algorithms by applying the principles of mathematics and science.	3
	PO 5	Understand the (knowledge) appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	3
CO 3	PO 1	(**Design**) a Test Plan which helps us to validate the quality of the application for finding the solution of **complex engineering**	1
	PO 5	Understand the (knowledge) appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	3
	PO 10	Recognize the importance of efficient sorting techniques for optimizing the efficiency of other algorithms that require input data to be in sorted by communicating effectively with engineering community.	3
CO 5	PO 1	Understand (knowledge) the basic concept of algorithm analysis which provides theoretical estimates for the resources needed by any algorithm for a given computational problem. These estimates provide an insight into reasonable directions of search for efficient algorithms by applying the principles of mathematics and science.	3
	PO 10	Recognize the importance of efficient sorting techniques for optimizing the efficiency of other algorithms that require input data to be in sorted by communicating effectively with engineering community.	3

CO 6	PO 1	Understand (knowledge) the basic concept of algorithm analysis which provides theoretical estimates for the resources needed by any algorithm for a given computational problem. These estimates provide an insight into reasonable directions of search for efficient algorithms by applying the principles of mathematics and science.	3
	PO 10	Recognize the importance of efficient sorting techniques for optimizing the efficiency of other algorithms that require input data to be in sorted by communicating effectively with engineering community.	3
CO 7	PO 1	Understand (knowledge) the basic concept of algorithm analysis which provides theoretical estimates for the resources needed by any algorithm for a given computational problem. These estimates provide an insight into reasonable directions of search for efficient algorithms by applying the principles of mathematics and science.	3
	PO 2	Build strong foundation of data Structures which tells the program how to store data in memory and forming some relations among the data and use them in design and development of new products.	3
	PO 3	Recognize the need of linear data structures such as linked list, array, stack and queue by designing solutions for complex Engineering problems in real-time.	2
	PSO 1	Acquire sufficient knowledge to develop real-time applications by making use of linear data structures in career building and higher studies.	3
CO 8	PO 1	(**Design**) a Test Plan which helps us to validate the quality of the application for finding the solution of **complex engineering**	3
	PO 5	Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	7
	PO 3	Understand the applications of basic data structures such as stacks, queues, linked lists in designing and developing solutions of complex engineering applications.	6
	PSO 1	Make use of modern computer tools for applying the basic data structure concepts in building real-time applications for a successful career.	2
CO 9	PO 1	(**Design**) a Test Plan which helps us to validate the quality of the application for finding the solution of **complex engineering**	3
	PO 2	Make use of non-linear data structures such as balanced trees in by identifying, formulating and analyzing complex engineering problems such as databases, syntax tree in compilers and domain name servers etc. with the help of basic mathematics and engineering sciences.	6

	PO 3	Extend the concept of tree data structures to design and develop solutions for complex engineering problems.	6
	PSO 1	Make use of modern computer tools in implementing non-linear data structures for various applications to become a successful professional in the domain.	2
CO 10	PO 1	Demonstrate different tree structures in Python to implement real-time problems by applying basic knowledge of science and engineering fundamentals.	3
	PO 2	Illustrate the importance of tree data structures used for various applications by identifying, formulating and analyzing complex engineering problems such as operating systems and compiler design.	6
	PO 3	Make use of tree data structures to design and develop solutions for complex engineering problems and which is the key organizing factor in software design. Data structures can be used to organize the storage and retrieval of information stored in both main memory and secondary memory.	6
	PSO 1	Acquire sufficient knowledge in field of data structures and its applications by using modern computer tools so that new product development can take place, which leads to become successful entrepreneur and or to obtain higher education.	2
CO 11	PO 1	Understand (knowledge) the benefits of dynamic and static data structures implementations and choose appropriate data structure for specified problem domain using knowledge of mathematics, science and engineering fundamentals.	3
	PO 2	Recognize the need of dynamic and static data structures in identifying, formulating and analyzing complex engineering problems.	4
	PO 3	Describe (knowledge) the usage of static and dynamic data structures in designing solutions for complex Engineering problems.	6
	PSO 1	Build sufficient knowledge of dynamic data structures by using modern tools so that new product can be developed, which leads to become successful entrepreneur in the present market.	2
CO 12	PO 1	Build strong foundation of quickly determining the efficiency of an algorithm or data structure for solving computing problems with respect to performance by using knowledge of mathematics, science and engineering fundamentals.	3
	PO 2	Recognize the importance of suitable data structures in checking the efficiency of algorithms used for complex engineering problems.	4
	PO 3	Make use of broad usage of data structures in designing and developing of complex engineering applications.	6

	PSO 1	Extend the concept of data structures in solving complex engineering problems using modern engineering tools to become a successful professional in the domain.	2

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

Course Outcomes	Program Outcomes					Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO12	PSO1	PSO2	PSO3
CO1	3							
CO2	3							
CO3	1							
CO4	1		3			3		
CO5						3		
CO6	3		2					

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO1, PO2,PO4	SEE Exams	PO1, PO2,PO4	Seminars	-
Laboratory Practices	PO1, PO2,PO4	Student Viva	PO1, PO2,PO4	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**SEARCHING TECHNIQUES**
	Write python program for implementing the following searching techniques. a. Linear search. b. Binary search. c. Fibonacci search
WEEK II	**SORTING TECHNIQUES**
	a. Write Python programs for implementing the following sorting techniques to arrange a list of integers in ascending order. a. Bubble sort. b. Insertion sort. c. Selection sort.
WEEK III	**SORTING TECHNIQUES**
	a. Write Python programs for implementing the following sorting techniques to arrange a list of integers in ascending order. a. Quick sort. b. Merge sort.
WEEK IV	**IMPLEMENTATION OF STACK AND QUEUE**
	Write Python programs to a. Design and implement Stack and its operations using Lists. b. Design and implement Queue and its operations using Lists.
WEEK V	**APPLICATIONS OF STACKL**
	Write Python programs for the following: a. Uses Stack operations to convert infix expression into postfix expression. b. Uses Stack operations for evaluating the postfix expression. .
WEEK VI	**IMPLEMENTATION OF SINGLE LINKED LIST**
	Write Python programs for the following: a. Uses functions to perform the following operations on single linked list. (i) Creation (ii) insertion (iii) deletion (iv) traversal b. To store a polynomial expression in memory using linked list.
WEEK VII	**IMPLEMENTATION OF CIRCULAR SINGLE LINKED LIST**
	Write Python programs for the following: Uses functions to perform the following operations on Circular linked list. (i) Creation (ii) insertion (iii) deletion (iv) traversal .
WEEK VIII	**IMPLEMENTATION OF DOUBLE LINKED LIST**
	Write Python programs for the following: Uses functions to perform the following operations on double linked list. (i) Creation (ii) insertion (iii) deletion (iv) traversal in both ways. .
WEEK IX	**IMPLEMENTATION OF STACK USING LINKED LIST**
	Write Python programs to implement stack using linked list.
WEEK X	**IMPLEMENTATION OF QUEUE USING LINKED LIST**
	Write Python programs to implement queue using linked list.
WEEK XI	**GRAPH TRAVERSAL TECHNIQUES**
	Write Python programs to implement the following graph traversal algorithms: a. Depth first search. b. Breadth first search. .
WEEK XII	**IMPLEMENTATION OF BINARY SEARCH TREE**
	Write a Python program that uses functions to perform the following: a. Create a binary search tree. b. Traverse the above binary search tree recursively in pre-order, post-order and in-order. Count the number of nodes in the binary search tree. .

TEXTBOOKS

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

Reference Books:

1. S. Lipschutz, "Data Structures", Tata McGraw Hill Education, 1st Edition, 2008.
2. Samanta, "Classic Data Structures", PHI Learning, 2nd Edition, 2004.Gottfried Byron,
3. "Schaum's Outline of Programming with Python", Tata Mc Graw Hill, 1st Edition, 2010.
4. Rance D. Necaise, "Data Structures and Algorithms using Python", Wiley, John Wiley & Sons, INC., 2011.
5. Benjamin Baka, David Julian, "Python Data Structures and Algorithms", Packt Publishing Ltd., 2017.

WEB REFERENCE:

1. https://docs.python.org/3/tutorial/datastructures.html
2. http://interactivepython.org/runestone/static/pythonds/index.html
3. http://www.tutorialspoint.com/data_structures_algorithms
4. http://www.geeksforgeeks.org/data-structures/
5. http://www.studytonight.com/data-structures/
6. http://www.coursera.org/specializations/data-structures-algorithms
7. http://cse01-iiith.vlabs.ac.in/

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Searching Techniques	CO 1	T1
2	Sorting Techniques	CO 2	T1
3	Sorting Techniques	CO 3	T1, T2
4	Implementation of Stack and Queue	CO 3, CO 4	T1, T2
5	Applications of Stack	CO 5, CO4	T1, W1
6	Implementation of Single Linked List	CO1, CO3	T1, W2
7	Implementation of Circular Single Linked List	CO 5	T1, W3
8	Implementation of Double Linked List	CO 5	T2, W3
9	Implementation of Stack Using Linked List	CO 4	T2, W2

10	Implementation of Queue Using Linked List	CO5	T2, W5
11	Graph Traversal Techniques	CO4, CO5	T2, W2
12	Implementation of Binary Search Tree	CO1	T1, W5

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design a Data Structure SpecialStack that supports all the stack operations like push(), pop(), isEmpty(), isFull() and an additional operation getMin() which should return minimum element from the SpecialStack. All these operations of SpecialStack must be O(1). To implement SpecialStack, you should only use standard Stack data structure and no other data structure like arrays, list, . etc.
2	In class, we studied binary search trees that do not allow us to insert duplicate elements. However, sometimes we do need to store duplicates. For example, a database of student marks might contain one record for every mark by every student; so if you've taken two courses, there will be two records with the same key (your student number) and different data (your two marks). To accomplish this, we might use a data structure called a "BST with duplicates", or BSTD.
3	The variable tos in the Stack class is the index of the array element that would be filled the next time push() is called. Modify the code so that tos is the index of the top element actually in use. In other words, tos is to be the index of the top array element occupied by a value that has been "pushed" onto the stack. Write your changes on the code above. Don't forget to fix the comments. You do not need to add preconditions as in part-a.
4	Given an adjacency matrix representation of a graph, describe with pseudo code an algorithm that finds a single path, if one exists, between any two different vertices.
5	There is a garage where the access road can accommodate any number of trucks at one time. The garage is building such a way that only the last truck entered can be moved out. Each of the trucks is identified by a positive integer (a truck_id). Write a program to handle truck moves, allowing for the following commands: a) On_road (truck_id); b) Enter_garage (truck_ id); c) Exit_garage (truck_id); d) Show_trucks (garage or road); If an attempt is made to get out a truck which is not the closest to the garage entry, the error message Truck x not near garage door.
6	How many non-null links are there in a binary tree with N nodes?
7	How can we remove loops in a linked list? What are the functions of fast and slow pointers?
8	Which data structures are applied when dealing with a recursive function?

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

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION

<table>
<tr><td>Course Title</td><td colspan="5">AEROSPACE STRUCTURES</td></tr>
<tr><td>Course Code</td><td colspan="5">AAEB07</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td colspan="5">FOUR</td></tr>
<tr><td>Course Type</td><td colspan="5">Core</td></tr>
<tr><td>Regulation</td><td colspan="5">IARE - R18</td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lectures</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>3</td><td>1</td><td>3</td><td>-</td><td>-</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Dr. V Varun, Associate Professor</td></tr>
</table>

I. COURSE OVERVIEW:

Aerospace structures deals with the behavior of aircraft structural elements subjected to inertial, aerodynamic, and maneuver loads under various flight conditions.This course emphasizes the analysis and design of thin walled beams, thin plates analysis by using energy methods. Further the design concepts of structural idealization, load analysis on wing, fuselage, and landing gears have been introduced to analyze, design and development of flight vehicles structural components.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AMEB03	II	Engineering Mechanics
UG	AAEB04	III	Mechanics of Solid.

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Aerospace Structures	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONALMETHODOLOGIES:

✔	PPT	✔	Chalk & Talk	✔	Assignments	✗	MOOCs
✔	Open Ended Experiments	✔	Seminars	✗	Mini Project	✔	Videos
✗	Others						

V. EVALUATION METHODOLOGY:

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

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
10 %	Remember
50 %	Understand
25 %	Apply
15 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 2), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (Table3).

Table 2: Assessment pattern for CIA

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

Continuous Internal Examination (CIE):

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

Quiz – Online Examination:

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

Alternative Assessment Tool (AAT):

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table 3**.**

Table 3: Assessment pattern for AAT

5 Minutes Video	Assignment	Tech-talk	Seminar	Open Ended Experiment
20%	30%	30%	10%	10%

VI. COURSE OBJECTIVES (COs)(Reframe)

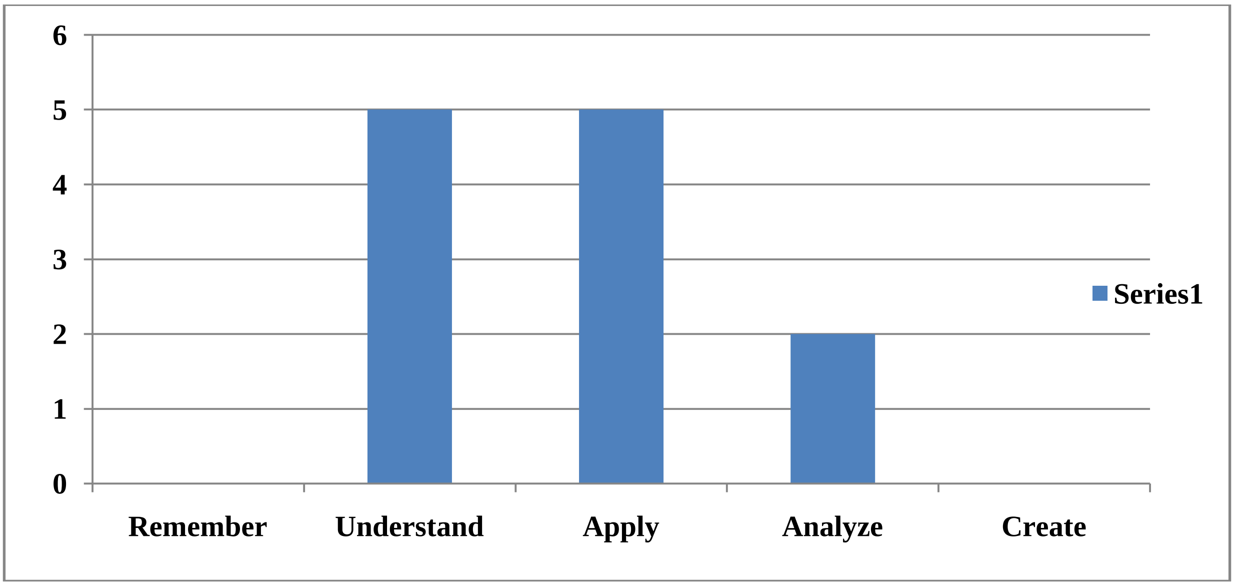
The students will try to learn:	
I	The application of mathematical principles on aircraft structural components and determination of deflections and stresses under various loading conditions.
II	The concepts of thin plate theory, phenomena of thin plate structural instability, analysis of bending, shear and torsion of thin walled beams
III	The concept of structural idealization and transformation of complex structures to simple structures.
IV	The behaviour of wing, fuselage and landing gears under various loading conditions.

VII. COURSE OUTCOMES(COs)

After successful completion of the course, students will be able to:		
	Course Outcomes	**Knowledge Level (Bloom's Taxonomy)**
CO 1	**Illustrate** the airplane structural components subjected to different loading conditions for determining its behaviour.	Understand
CO 2	**Apply** energy principles to aircraft structural components with different boundary conditions and loads for predicting deflections.	Apply
CO 3	**Explain** the concept of thin rectangular plates subject to various boundary conditionsfor obtaining deflection curves.	Understand

CO 4	**Analyze** various loads acting on thin plates with different boundary conditions for efficient design of monoques structures.	Analyze
CO 5	**Apply** beam bending concept on thin walled beam structures for predicting deflections and stresses in out of plane.	Apply
CO 6	**Analyze** the deflection and twist produced in thin walled open and closed section beams under torsion loads for designing beams with minimum stresses.	Analyze
CO 7	**Apply** the concept of elementary bending theory for predicting warping and torsion of aircraft structural components.	Apply
CO 8	**Explain** the concepts in structural idealization for transforming complex structural geometries to simple structural geometries.	Understand
CO 9	**Apply** the concept of structural idealization for determining deflections in open and closed section beams	Apply
CO 10	**Illustrate** the concept of beam bending to tapper wing, and cutout sections in wing and fuselage for predicting deflections and stresses.	Understand
CO 11	**Apply** the concept of maximum stress theories to aircraft structural components for determining failure loads.	Apply
CO 12	**Interpret** the load interaction between various aircraft components, for determining maximum stress.	Understand

COURSE KNOWLEDGE COMPETENCY LEVELS



VIII. HOW PROGRAM OUTCOMES AREASSESSED:

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

PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Seminar/ Conferences/ Research Papers
PO 5	**Modern Tool Usage:** 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	Assignments/ Discussion
PO 9	**Individual and Teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	2	Class group/ Multi-disciplinary Group
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	Discussion on Innovations/ Presentation
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	Research paper analysis/ Short term courses

3 = High; 2 = Medium; 1 = Low

IX. HOW PROGRAM SPECIFIC OUTCOMES AREASSESSED:

Program Specific Outcomes		Strength	Proficiency assessed by
PSO 1	**Professional skills:** Able to utilize the knowledge of aeronautical/aerospace engineering in innovative, dynamic and challenging environment for design and development of new products	2	Assignments
PSO 2	**Problem solving skills:** imparted through simulation language skills and general purpose CAE packages to solve practical, design and analysis problems of components to complete the challenge of airworthiness for flight vehicles	2	Assignments
PSO 3	**Practical implementation and testing skills:** Providing different types of in house and training and industry practice to fabricate and test and develop the products with more innovative technologies	2	Laboratory
PSO 4	**Successful career and entrepreneurship:** To prepare the students with broad aerospace knowledge to design and develop systems and subsystems of aerospace and allied systems and become technocrats	-	-

3 = High; 2 = Medium; 1 = Low

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

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	√	-	-	-	√	-	-	-	-	√	-	-	-	-	-
CO 3	√	√	-	-	-	-	-	-	-	-	-	-	-	-	√
CO 4	√	√	-	-	-	-	-	-	√	-	-	-	-	-	-
CO 5	√	-	-	-	√	-	-	-	-	√	-	-	-	-	-
CO 6	√	√	-	√	-	-	-	-	√	-	-	-	-	-	√
CO 7	√	√	-	√	-	-	-	-	-	-	-	-	-	√	-
CO 8	√	√	-	-	√	-	-	-	-	-	-	-	-	-	-
CO 9	√	-	-	-	-	-	-	-	-	√	-	-	-	-	√
CO10	√	-	-	-	√	-	-	-	√	-	-	-	-	-	√
CO11	√	√	-	√	-	-	-	-	-	-	-	-	-	-	√
CO12	√	-	-	-	-	-	-	-	-	-	-	√	-	√	-

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

Course Outcomes	POs / PSOs	Justification for mapping (Students will be able to)	No. of key competencies
CO 1	**PO 1**	Identify (knowledge) different aircraft structural components and understand the loads acting on it in solving (complex) structural engineering problems by applying the **principles of mathematics, science and engineering fundamentals.**	3
	PSO 3	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of Aerospace structures.	2
CO 2	**PO 1**	**Recognize** (knowledge) the importance and application (apply) of Energy methods for different structural components in solving (complex) structural engineering problems with (apply) different boundary conditions **by applying the principles of mathematics , science and engineering fundamentals.**	3
	PO 2	Understand the given **problem statement** and **formulate** (complex) structural engineering problem and system for determining various parameters of Energy method from the provided **information** and substantiate with the **interpretation** of variations in **the results**.	4
CO 3	**PO 1**	**Explain** (understanding) various deflection curves in thin plates subjected to various boundary conditions (apply) in solving (complex) plate bending problems by applying **the principles of mathematics, science and engineering fundamentals.**	3

CO 4	**PO 1**	**Apply** the basic conservation principles of **science** to thin plates and use **mathematical principles** for deriving (complex) plate bending equations by understanding the appropriate parametric assumptions and limitations based **on engineering fundamentals** of solid mechanics.	3
	PO 2	**Understand** the given **problem statement** and **formulate** (complex) Energy method to structural engineering phenomena and system for determining various governing equations of thin plates from the provided **information** and substantiate with the **interpretation of** variations in the **results**.	4
	PSO 3	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of structural engineering.	2
CO 5	**PO 1**	Determine several **scientific/physical/Engineering properties and parameters** of (complex) thin walled beam structural engineering problems by applying **solid mechanics governing equations** related to different **core and interdisciplinary engineering** practical scenarios.	3
	PO 2	Understand the given **problem statement** and **formulate** (complex) thin plate bending problems related to various governing laws of solid mechanics from the provided **information** and data in reaching substantiated conclusions by the **interpretation of results**.	4
	PSO 3	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of Aerospace structures.	2
CO 6	**PO 1**	Relate (knowledge, understand and apply) the deflection and twist produced in thin walled beams under torsion in solving (complex) engineering problems by applying the principles of **mathematics, science and structural engineering fundamentals**.	3
	PO 2	Understand the given **problem statement** and **formulate** deflection of thin walled beams to solve (complex) engineering problems from the provided **information and data** for reaching substantiated conclusions by the i**nterpretation** of results.	4
	PO 4	**Recognize (knowledge) the characteristics** of thin-walled beams by understanding the **corresponding context to the engineering knowledge, technical uncertainty** of beams causing the stresses, **analyze key regimes** maximum stress by applying the displacement measures incorporating the **systems approach**.	5
CO 7	**PO 1**	Model the thin wall aerospace structures with bending theory in solving (complex) structural engineering problems for predicting warping by **applying** the principles of **mathematics, science**, and **engineering fundamentals** of solid mechanics.	3
	PSO 3	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of Aerospace structures.	2
CO 8	**PO 1**	Explain (understanding) the theory of structural idealization and principles (knowledge) to thin-walled panels and their applicability (apply) in solving (complex) engineering problems related to direct stresses by applying **the principles of structural engineering fundamentals and their integration and support with other engineering disciplines, mathematics, science.**	3

	PO 2	Understand the given **problem statement** and **formulate** the design (complex) engineering problems of aircraft structure from the provided **information and data** in reaching substantiated conclusions by the **interpretation of results**.	4
	PSO 3	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of structural mechanics.	2
CO 9	**PO 1**	Illustrate the deflection of open and closed section beams understanding the knowledge in solving (complex) engineering problems related to structural idealization by applying the principles of solid mechanics to **engineering fundamentals** and their integration and support with other engineering disciplines, trigonometry **(mathematics), and scientific methodologies.**	3
	PO 2	Understand the given **problem statement and formulate** the design (complex) engineering problems of structural idealization, translate the **information** into the illustration of deflection of various beams from the provided information and data, **develop solutions** based on the applied load and boundary conditions, **validate** the illustrated deflection and stresses in reaching substantiated conclusions by the **interpretation of results**.	7
CO 10	**PO 1**	Evaluate the deflections and stresses for solving (complex) engineering problems related to tapered wings by applying the principles of structural **engineering fundamentals** and their **integration and support with other engineering disciplines, mathematics, and scientific methodologies.**	3
	PO 2	Understand the given **problem statement** and **formulate** the deflection (complex) engineering problems of wing section, **translate the information** into the model and prototype systems from the provided **information and data, develop solutions** based on the loads, validate the deflection in reaching substantiated conclusions by the **interpretation of results**.	7
CO 11	**PO 1**	Judge the stresses acting on aircraft structural components by solving (complex) engineering problems related to maximum stress by applying the principles of structural **engineering fundamentals** and their integration and support with other **engineering disciplines, mathematics, and scientific methodologies.**	3
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems of aircraft components, **translate the information** into the model and prototype systems from the provided **information and data, develop solutions** based on the maximum stress theories and **validate** the component in reaching substantiated conclusions by the **interpretation of results**.	7
	PSO 2	Extend the focus to **understand the innovative and dynamic challenges** involving the thin walled beams of aircraft structures for specific role.	1
CO 12	**PO 1**	Choose the designing procedure of aircraft components like wing for solving (complex) engineering problems related to aircraft structures along with enhanced performance and minimized weight by applying the principles of structural engineering fundamentals and their integration and support with other engineering disciplines, mathematics, and scientific methodologies.	3

	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems of aircraft structures like wing, **translate the information** into the model and prototype systems from the provided **information and data, develop solutions** based on the **functionality of the component**, **validate** the wing structure in reaching **substantiated conclusions by the interpretation of results**.	7
	PO 12	Make use of broad knowledge of materials and composites in **innovative, dynamic challenging** environment for **design and development** of new designs.	4
	PSO 1	**Synthesize** and **analyze** different wing and fuselage systems for light weight aircrafts to provide good strength to weight ratio for the different aircrafts	2

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

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

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

Course Outcomes	**Program Outcomes / No. of key competencies**												**PSOs / No. of key Competencies**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
	3	**10**	**10**	**11**	**1**	**5**	**3**	**3**	**12**	**5**	**12**	**12**	**2**	**1**	**2**
CO 1	100.0	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

CO 2	66.7	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	80.0	0.0	0.0	0.0	0.0	0.0
CO 3	66.7	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0
CO 4	100.0	70.0	0.0	0.0	0.0	0.0	0.0	0.0	58.3	0.0	0.0	0.0	0.0	0.0	0.0
CO 5	66.7	70.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	80.0	0.0	0.0	0.0	0.0	0.0
CO 6	66.7	70.0	0.0	80.0	0.0	0.0	0.0	0.0	67.0	0.0	0.0	0.0	0.0	0.0	100.0
CO 7	100.0	70.0	0.0	70.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
CO 8	66.7	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 9	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.0	0.0	0.0	0.0	0.0	100.0
CO 10	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	50.0
CO 11	100.0	70.0	0.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
CO 12	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	75.0	0.0	100.0	0.0

XIV. COURSE ARTICULATION MATRIX (PO – PSOMAPPING)

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

0 – **0**≤ C≤ 5%–No correlation

1 – 5 <C≤ 40% –Low/ Slight

2 − 40 % <C< 60%–Moderate

3 – 60% ≤ C< 100% – Substantial/High

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

TOTAL	31	18		9	12				8	9		3		6	13
AVERAGE	**2.6**	**3.0**		**3.0**	**3.0**				**2.7**	**3.0**		**3.0**		**3.0**	**2.6**

XV. ASSESSMENT METHODOLOGY –DIRECT

CIE Exams	PO1,PO2	SEE Exams	PO1,PO2, PO4	Assignments	-	Seminars	-
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-	Concept Video	PO5	Tech talk	PO10	Open-ended Experiments	PO5,PO8, PO12

XVI. ASSESSMENT METHODOLOGY –INDIRECT

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

XVII. SYLLABUS

MODULE-I	**INTRODUCTION TO AIRCRAFT STRUCTURAL COMPONENTS AND ENERGY METHODS**
Aircraft Structural components and loads, functions of structural components, airframe loads; Types of structural joints, type of loads on structural joints; Aircraft inertia loads; Symmetric manoeuvre loads, gust loads. Monocoque and semi monocoque structures, stress in thin and thick shells; Introductions to energy principles, castiglianos theorems, max wells reciprocal theorem, unit load method, Rayleigh Ritz method, total potential energy method, flexibility method.	
MODULE -II	**THIN PLATE THEORY, STRUCTURAL INSTABILITY**
Analysis of thin rectangular plates subject to bending, twisting, distributed transverse load, combined bending and in-plane loading: Thin plates having small initial curvature, energy methods of analysis. Buckling of thin plates: Elastic, inelastic, experimental determination of critical load for a flat plate, local instability, instability of stiffened panels, failure stresses in plates and stiffened panels. Tension field beams- complete diagonal tension, incomplete diagonal tension, post buckling behavior.	
MODULE-III	**BENDING, SHEAR AND TORSION OF THIN WALLED BEAMS**
Unsymmetrical bending: Resolution of bending moments, direct stress distribution, position of neutral axis; Deflections due to bending: Approximations for thin walled sections, temperature effects; Shear loaded thin walled beams: General stress, strain and displacement relationships, direct stress and shear flow system, shear centre, twist and warping. Torsion of beams of closed section: Displacements associated with Bredt-Batho shear flow; Torsion of open section beams; Warping of cross section, conditions for zero warping; Bending, shear, torsion of combined open and closed section beams.	
MODULE-IV	**STRUCTURAL IDEALIZATION**
Structural idealization: Principal assumptions, idealization of panel, effect on the analysis of thin walled beams under bending, shear, torsion loading- application to determining deflection of open and closed section beams. Fuselage frames - bending, shear and torsion.	
MODULE-V	**ANALYSIS OF FUSELAGE, WING AND LANDING GEAR**
Wing spar and box beams, tapered wing spar, open and closed sections beams, beams having variable stringer areas; wings – three boom shell in bending, torsion and shear, tapered wings, deflections,	

cutouts in wings; Cutouts in fuselages; Fuselage frame and wing rib; principle of stiffener, web constructions. Landing gear and types; Analysis of landing gear.
TEXT BOOKS:
1. T. H. G. Megson, "Aircraft Structures", Butterworth-Heinemann Ltd, 5th Edition, 2012. 2. E. H. Bruhn, "Analysis and Design of Flight vehicles Structures", Tri-state off set company, USA, 4th Edition, 1965.
REFERENCES:
1. B. K. Donaldson, "Analysis of Aircraft Structures - An Introduction", McGraw Hill, 3rd Edition, 1993. 2. S. Timoshenko, "Strength of Materials", Volumes I and II, Princeton D. Von Nostrand Co., Reprint, 1977.

XVIII. COURSEPLAN:

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

Lecture No	Topics to be covered	COs	Reference
1-3	Aircraft Structural components and loads.	CO1,CO2	T1:12.1
4-6	Functions of structural components, airframe loads.	CO1,CO2	T1:12.2
7-8	Types of structural joints, typeof loads on structural joints; Aircraft inertia loads.	CO1	T1:12.3
9-11	Symmetric maneuver loads, gust loads. Monocoque and semi monocoque structures, stress in thin and thick shells.	CO2	T1:14.2 R2:IV.25
12-14	Introductions to energy principles, castiglianos theorems, max wells reciprocal theorem, unit load method.	CO2,CO2	T1:5.5 T1:5.10
15-17	Rayleigh Ritz method, total potential energy method, flexibility method.	CO2 ,CO1	T1:5.6 T2:15.2
18-20	Analysis of thin rectangular plates subject to bending, twisting, distributed transverse load, combined bending and in-plane loading.	CO3,CO4	T2:C5.6 R1:22.5
21-23	Thin plates having small initial curvature, energy methods of analysis. Buckling of thin plates: Elastic, inelastic, experimental determination of critical load for a flat plate.	CO3,CO4	T1:9.1 R1:22.6
24-26	Local instability, instability of stiffened panels, failure stresses in plates and stiffened panels. Tension field beams- complete diagonal tension, incomplete diagonal tension, post buckling behavior.	CO4	T2:A18.20 T2:C11.1
27-30	Unsymmetrical bending: Resolution of bending moments, direct stress distribution, position of neutral axis.	CO4,CO3	T1:16.1
31-33	Deflections due to bending: Approximations for thin walled sections, temperature effects.	CO4,CO3	T1:16.6
34-37	Shear loaded thin walled beams: General stress, strain and displacement relationships, direct stress and shear flow system, shear centre, twist and warping.	CO5	T1:17.1
38-39	Torsion of beams of closed section: Displacements associated with Bredt-Batho shear flow; Torsion of open section beams.	CO5,CO6	T2:A6.4 R2:X.62
40	Warping of cross section, conditions for zero warping; Bending, shear, torsion of combined open and closed section beams.	CO6,CO5	T1:18.1.2
41	Structural idealization, Principal assumptions.	CO6	T1:20.1

Lecture No	Topics to be covered	COs	Reference
42-43	Idealization of panel, effect on the analysis of thin walled beams under bending, shear, torsion loading.	CO7,CO8	T1:20.2
44-45	Application to determining deflection of open and closed section beams.	CO7	T1:16.3
46	Fuselage frames - bending, shear and torsion.	CO8,CO7	T1:24.2
47-50	Wing spar and box beams.	CO10,CO11	T2:A22.5
51-53	Open and closed sections beams, beams having variable stringer areas.	CO11,CO12	T1:27.1
53	Wings – three boom shell in bending, torsion and shear, tapered wings, deflections, cutouts in wings.	CO12,CO11	T1:23.8 T2:A19.14
54-55	Cutouts in fuselages; Fuselage frame and wing rib; principle of stiffener, web constructions. Landing gear and types; Analysis of landing gear.	CO12,CO11	T1:22.4 T2:A5.18
DEFINITIONS AND TERMINOLOGY			
56	Module: I	CO 1,CO 2	
57	Module: II	CO 4,CO 5	
58	Module: III	CO 6,CO 7	
59	Module: IV	CO 8,CO 9	
60	Module: V	CO10,CO11	
TUTORIAL QUESTION BANK			
61	Module: I	CO 1,CO 2	
62	Module: II	CO 4,CO 5	
63	Module: III	CO 6,CO 7	
64	Module: IV	CO 8,CO 9	
65	Module: V	CO10,CO11	

Prepared by:
Dr.V.Varun, Associate Professor **HOD,AE**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**AERODYNAMICS**				
Course Code	AAEB10				
Program	B.Tech				
Semester, Branch	FOUR				
Course Type	CORE				
Regulation	IARE – R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	-	-
Course Coordinator	Dr. K Maruthupandiyan,Associate Professor				

I. COURSE OVERVIEW:

Aerodynamics course focuses on the study of the flow of air about a body, and thebody can be an airplane, but many of the concepts explored are relevant to a wide variety of applications from sailboats, automobilesand birds. This course will enable learners to gain a fundamental understanding of concepts and models used to aerodynamically analyze and some classical theories which are useful for design of aircraft components. As this course is an introduction to aerodynamics, it is prerequisite course for high speed aerodynamics as well as can be an advanced subject for students with aerodynamics as specialization.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB03	III	Fluid dynamics

II. MARKSDISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Aerodynamics	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V. EVALUATION METHODOLOGY:

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

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
0 %	Remember
55 %	Understand
45%	Apply
0 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 2), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (Table 3).

Table 2: Assessment pattern for CIA

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

Continuous Internal Examination (CIE):

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

Quiz –Online Examination:

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

Alternative Assessment Tool (AAT):

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours / classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table 3**.**

Table 3: Assessment pattern for AAT

5 Minutes Video	Assignment	Tech-talk	Seminar	Open Ended Experiment
20%	30%	30%	10%	10%

VI.COURSE OBJECTIVES:

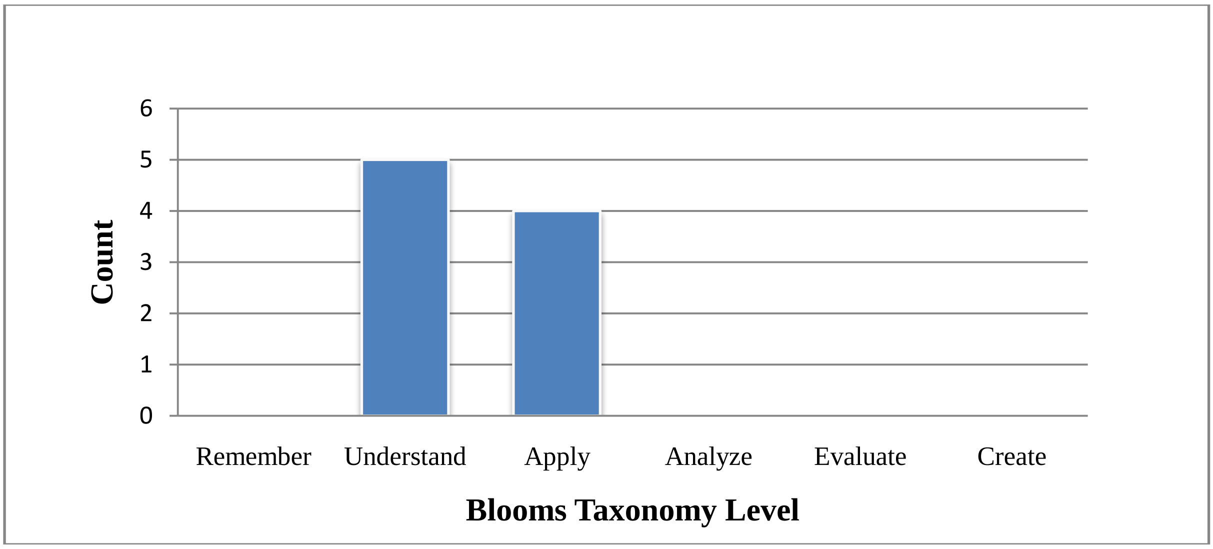
The students will try to learn:	
I	The fundamental knowledge on basics of aerodynamics and aerodynamic characteristics of wings, airfoils.
II	The mathematical model for lift and drag coefficient of finite wing and wing of infinite aspect ratio.
III	The flow over non-lifting bodies from method of singularities and investigate the interference effect
IV	The effect of viscosity and boundary layer growth over various shaped geometry and its control.

VII. COURSE OUTCOMES:

After successful completion of the course, students will be able to:		
	Course Outcomes	**Knowledge Level (Bloom's Taxonomy)**
CO 1	**Explain** the velocity potential, stream function and their importance for solving the flow over arbitrary shape.	Understand
CO 2	**Develop** the mathematical model using method of singularities for non-lifting, lifting flow over circular cylinder	Apply
CO 3	**Illustrate** various types of airfoil,their nomenclature and aerodynamic characteristics for its suitable selection**.**	Understand

CO 4	**Solve** the lift characteristics of wing of infinite aspect ratio from classical thin airfoil for real world applications	Apply
CO 5	**Construct** the mathematical model using the concept of Prandtl's lifting line theory for wing of finite aspect ratio.	Apply
CO 6	**Summarize** the effect of wing twist, wing taper and wing sweep for perceiving the aerodynamic characteristics of finite wing.	Understand
CO 7	**Apply** vortex panel and vortex lattice methods forflow over non-lifting bodies	Apply
CO 8	**Demonstrate** the effect of propeller slipstream flow on the aerodynamic characteristics of wing and tail unit	Understand
CO 9	**Interpret** the regimes and separation of boundary layer growth over external fluid flow systems for identifying its effect on boundary layer properties	Understand

KNOWLEDGE COMPETENCY LEVELS:



VIII.HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIA/SEE
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIA/SEE
PO 9	**Individual and Teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	1	Class group / Multi-disciplinary group

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	Group Discussion
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	CIA/SEE

3 = High; 2 = Medium; 1 = Low

IX. HOW PROGRAM SPECIFIC OUTCOMES AREASSESSED:

Program Specific Outcomes		Strength	Proficiency assessed by
PSO 1	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards	3	Quiz
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic and challenging environment for design and development of new products	1	Seminars

3 = High; 2 = Medium; 1 = Low

X. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

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

XI. JUSTIFICATIONS FOR CO – PO MAPPING:

Course Outcomes	POs / PSOs	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	**PO 1**	Explain (understanding)the velocity potential, stream functionand to a considerable extent appreciate (understanding) their importance and applicability (apply) in solving (complex) fluid flow engineering problems by applying the principles of **mathematics, science and Engineering**	3
	PO2	Understand the (**given problem statement** and **formulate)** properties, various types and patterns of fluid flow configurations (provided **information** and **data)** in reaching substantiated conclusions by the interpretation of results	4
	PSO 2	Apply (knowledge) properties, various types and patterns of fluid flow configurations (apply) for solving design problems by applying the principles of **mathematics**, **science**and **Engineering**	3
CO 2	**PO 1**	Explain (understanding) the methods to create mathematical model using method of singularities for non-lifting, lifting flow over circular cylinder(apply) and., in solving (complex) fluid flow engineering problems by applying the principles of **mathematics, science and engineering fundamentals.**	3
	PO2	Understand the (given **problem statement** and **formulate)**method of singularities for non-lifting, lifting flow over circular cylinder. (from the provided **information** and **data)** in solving problems.	4
	PSO 2	Apply (knowledge) method of singularities for non-lifting, lifting flow over circular cylinder (apply) in solving flow over arbitrary bodies by applying the principles of **mathematics, science** and **Engineering**	**3**
CO 3	**PO 1**	Summarize (knowledge) the various types of airfoil, their nomenclature and aerodynamic characteristics (understanding) their importance and applicability (apply) in solving (complex) fluid flow engineering problems by applying the principles of **mathematics, science**.	3
	PO 2	Understand the given **problem statement** and formulate (complex) various types of airfoil, their nomenclature and aerodynamic characteristics (understanding) their importance and applicability (apply) in solving (complex) fluid flow engineering problems from the provided information and substantiate with the **interpretation** of variations in the **results.**	4
	PSO2	Apply (knowledge)Nomenclature of various airfoils and their aerodynamic characteristics (apply) in solving aircraft analysis problems by applying the principles of **mathematics, science** and **Engineering**	3
CO 4	**PO 1**	Recognize (knowledge) the importance and application (apply) of the lift characteristics of wing of infinite aspect ratio from classical thin airfoil in solving (complex) engineering problems with specific emphasis to fluid mechanics by applying the principles of **mathematics and engineering fundamentals**.	3

	PO 2	Understand the given **problem statement** and formulate the lift characteristics of wing of infinite aspect ratio from classical thin airfoil for predicting physical parameters that govern fluid systems in designing prototypes devices	4
	PO9	**Individual and Teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings of aerodynamic design.	**5**
	PO 12	Make use of broad knowledge of thin airfoil theory in **innovative, dynamic challenging environment for design and development of new products**.	2
	PSO 2	Apply (knowledge) concept of thin airfoil theory for predicting physical parameters (understanding) for the fluid flow analysis used in designing prototypes devices (apply) solving design problems by applying the principles of **mathematics, science** and **Engineering**	**3**
CO 5	**PO 1**	Apply the concept of Prandtl's lifting line theory and use **mathematical principles** for deriving (complex) the mathematical model for wing of finite aspect by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals** of aerodynamics.	3
	PO 2	Understand the given **problem statement** and formulate (complex) fluid flow engineering phenomena and system for deriving Prandtl's lifting line equation for wing if finite aspect ratio from the provided information and substantiate with the **interpretation** of variations in the **results.**	4
	PO 3	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of aerodynamics.	3
	PSO 2	Apply (knowledge Prandtl's lifting line theory for wing of finite aspect artio (understanding) with appropriate parametric assumptions and limitations (apply) in solving design problems by applying the principles of **mathematics, science** and **Engineering**	3
CO 6	**PO 1**	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles to** understand the effect of wing twist, wing taper and wing sweep on the aerodynamic characteristics of finite wing.	3
	PO 2	Using the effect of wing twist, wing taper and wing sweep on the aerodynamic characteristics of finite wing**to analyze complex fluid flow problems using principles of mathematics and engineering sciences.**	2
CO 7	**PO 1**	Relate (**knowledge**, understand and apply) vortex panel and vortex lattice methods (complex)for flow over non-lifting bodies by applying the principles of **mathematics, science and fluid engineering fundamentals**.	3
	PO 2	Understand the given **problem statement** and **formulate**the methods of vortex panel and vortex lattice techniques (complex) for engineering problems from the provided **information and data** in reaching substantiated conclusions by the **interpretation of results**.	4
	PO 4	**Recognize (knowledge) the characteristics** of vortex panel and vortex lattice methods, understand the corresponding context of the **engineering knowledge, technical**	5

		uncertainty, for flow over non-lifting bodiesanalyze key aspects of each methods by incorporating the **systems approach**.	
	PSO 2	Explain (knowledge) vortex panel and vortex lattice methods(apply) for flow over non-lifting bodiesby applying the principles of **mathematics, science** and **Engineering**	**3**
CO 8	**PO 1**	**Apply** the **knowledge of mathematics, science and engineering fundamentals** for determining the effect of propeller slipstream flow on the aerodynamic characteristics of wing and tail for designing the new device as per the requirements.	3
	PO 2	**Using first principles and Sciences and Engineering sciences** understand the effect of propeller slipstream flow on the aerodynamic characteristics of wing and tail for designing desired equipment's	2
	PSO2	Extend the focus to **understand the innovative and dynamic challenges** involves in evaluation of aircraft performance under the effect of propeller slip stream.	2
CO 9	**PO 1**	Relate (**knowledge**, understand and apply) the regimes and separation of boundary layer during external fluid flow(complex) engineering problems by applying the principles of **mathematics, science and fluid engineering fundamentals**.	3
	PO 2	Understand the given **problem statement** and **formulate** boundary layer phenomena of external fluid flow (complex) engineering problems from the provided **information and data** in reaching substantiated conclusions by the **interpretation of results**.	4
	PO 4	**Recognize (knowledge) the characteristics** of boundary layer regimes and processes, understand the corresponding context of the **engineering knowledge, technical uncertainty** of the boundary layer causing the separation, analyze key regimes of the boundary layer by applying the displacement measures incorporating the **systems approach**.	5
	PSO 2	Apply (knowledge) the regimes and separation of boundary layer during external fluid flow systems (apply) identifying its effect in reduction of displacement, momentum and energy thickness gradients by applying the principles of **mathematics, science** and **Engineering**	**3**

XII.NUMBER OF KEY COMPETENCIES FOR CO – PO MAPPING:

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

CO 3	3	4	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 4	3	4	-	-	-	-	-	-	5	-	-	2	-	3	-
CO 5	3	4	3	-	-	-	-	-	-	-	-	-	-	3	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 7	3	4	-	5	-	-	-	-	-	-	-	-	-	3	-
CO 8	3	2	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 9	3	4	-	5	-	-	-	-	-	-	-	-	-	3	-

XIII.PERCENTAGE OF KEY COMPETENCIES FOR CO – PO MAPPING:

Course Outcomes	Program Outcomes / No. of key competencies												PSOs / No. of key competencies		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
	3	**10**	**10**	**11**	**1**	**5**	**3**	**3**	**12**	**5**	**12**	**12**	**1**	**2**	**2**
CO 1	100	40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0.0
CO 2	100	40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0.0
CO 3	100	40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0.0
CO 4	100	40	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	100	0.0
CO 5	100	40	30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0.0
CO 6	100	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 7	100	40	0.0	47.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0.0
CO 8	100	20	0.0	45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0.0
CO 9	100	40	0.0	47.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0.0

XIV.COURSE ARTICULATION MATRIX (PO – PSO MAPPING)

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

0 – **0**≤ C≤ 5% – No correlation
1 – 5 <C≤ 40% – Low/ Slight
2 – 40 % <C< 60% –Moderate
3 – 60% ≤ C< 100% – Substantial /High

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

CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 4	3	2	-	-	-	-	-	-	1	-	-	-	-	3	-
CO 5	3	2	1	-	-	-	-	-	-	-	-	-	-	3	-
CO 6	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 7	3	2	-	2	-	-	-	-	-	-	-	-	-	3	-
CO 8	3	1	-	2	-	-	-	-	-	-	-	-	-	3	-
CO 9	3	2	-	2	-	-	-	-	-	-	-	-	-	3	-
TOTAL	27	16	1	6	-	-	-	-	1	-	-	-		3	-
AVERAGE	**3.0**	**1.8**	**1**	**2**	**-**				1			-		**3.0**	

XV. ASSESSMENT METHODOLOGIES–DIRECT

CIE Exams	PO 1,PO 2, PSO 2	SEE Exams	PO 1,PO 2, PSO 2	Assignments	PO 1,PO 2, PSO 2	Seminars	PO 1
Laboratory Practices	PO 1,PO 2, PSO 2	Student Viva	PO 10	Mini Project	PO 1,PO 2, PSO 2	Certification	-
Term Paper	PO 9 PO 10	5Minutes Video	PO 9 PO 10	Tech Talk	PO 9 PO 10	Open Ended Experiments	-

XVI. ASSESSMENT METHODOLOGIES–INDIRECT

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

XVII. SYLLABUS

Module-I	**INTRODUCTORY TOPICS FOR AERODYNAMICS**
Potential flow, velocity potential, stream function, Laplace equation, flow singularities-Uniform flow, source, sink, doublet, Vortex, Non lifting and lifting flow over a cylinder Kutta-Joukowski theorem.	
Module-II	**THIN AEROFOIL THEORY**
Aerofoil nomenclature, aerodynamic characteristics, centre of pressure and aerodynamic centre; Wing of infinite aspect ratio, C_L-α- diagram for a wing of infinite aspect ratio, generation of lift, starting Vortex, Kutta‘s trailing edge condition; Thin aerofoil theory; Elements of panel method; High lift airfoils, High lift devices.	

Module-III	FINITE WING THEORY
Vortex motions, vortex line, vortex tube, vortex sheet; Circulation; Kelvin and Helmhotz theorem; Biot-Savart's law, applications, Rankine's vortex; Flow past finite wings, vortex model of the wing and bound vortices; Induced drag; Prandtl's lifting line theory; Elliptic wing. Influence of taper and twist applied to wings, effect of sweep back wings; Delta wings, primary and secondary vortex; Elements of lifting surface theory. Source Panel Vortex panel and Vortex lattice methods.	
Module-IV	**FLOW PAST NON-LIFTING BODIES AND INTERFERENCE EFFECTS**
Flow past non lifting bodies, method of singularities; Wing-body interference; Effect of propeller on wings and bodies and tail unit; Flow over airplane as a whole.	
Module-V	**BOUNDARY LAYERTHEORY**
Introduction to boundary layer, laminar and turbulent boundary layer, transition, boundary layer on flat plate, displacement thickness, momentum thickness, energy thickness, effect of curvature, temperature boundary layer.	
Text Books:	
1. E. L. Houghton and P. W. Carpenter, ―Aerodynamics for Engineering Students‖, Edward Arnold Publishers Ltd., London, 5th Edition, 1982, 2. J. D. Anderson, ―Fundamentals of Aerodynamics, Mc Graw Hill Book Co., New York, 5th Edition, 1985. 3. John J. Bertin and Russell M. Cummings, ―Aerodynamics for Engineering Students‖, Pearson, 5th Edition, 2009.	
Reference Books:	
1. L. J. Clancy, ―Aerodynamics‖, Pitman, 1st Edition, 1986. 2. L. H. Milne, S. Thomson, ―Theoretical Aerodynamics‖, Dover, 2nd Edition, 1985. 3. K. Karamcheti, ―Principles of Ideal-Fluid Aerodynamics‖, Krieger Pub Co; 2nd edition, 1980.	

VIII. COURSE PLAN:

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

Lecture No	Topics to be covered	Course Outcomes	Reference
1	Potential flow	CO1	T2:104-105
2	Velocity potential	CO1	T2:105-109
2	Stream function	CO1	T2:109-110
3	Laplace equation	CO1	T2:109
3	Flow singularities	CO1	T2:104-105 R1:3.2
4	Uniform flow	CO1	T2:119-130 R1:3.2
4	Source	CO1	T2:119-130 R1:3.3
5	Sink	CO2	T2:119-130 R1:3.4
6	Doublet	CO2	T2:119-130 R1:3.5

Lecture No	Topics to be covered	Course Outcomes	Reference
7	Vortex	CO2	T2:119-130 R1:3.6
8	Non lifting and lifting flow over a cylinder	CO2	T2:131-132 R1:3.7
9	Kutta-Joukowski theorem	CO2	T2:167 R1:3.7
10	Aerofoil nomenclature	CO3	T2: 192 R2:8.1
11	Aerodynamic characteristics	CO3	T1:4.3 R2:8.1
11	Centre of pressure	CO3	T1:1.6-4.9 R2:8.2
11	Aerodynamic centre	CO3	T1:1.6-4.9
12	Wing of infinite aspect ratio	CO3	T1:1.6-4.9
13	CL-α- diagram for a wing of infinite aspect ratio	CO3	T1:4.7
14	Generation of lift	CO3	T1:4.7
15	Starting Vortex	CO4	T1:4.5
15	Kutta’s trailing edge condition	CO4	T1:4.6 R2:8.3
16	Thin aerofoil theory	CO4	T1:4.7- 4.10 R2:8.3
17	Elements of panel method	CO4	T1:4.10
18	High lift airfoils	CO4	T1:4.12
18	High lift devices	CO4	T1:4.12
19	Vortex motions	CO5	T1:5.2 R2:11.1
20	Vortex line	CO5	T1:5.2 R2:11.1
20	Vortex tube	CO5	T1:5.2 R2:11.1
20	Vortex sheet	CO5	T1:5.2 R2:11.1
21	Circulation	CO5	T1:4.6
22	Kelvin and Helmhotz theorem	CO5	T1:4.6
23	Biot-Savart‘s law & applications	CO5	T1:5.2
24	Rankine‘s vortex	CO5	T1:5.3
25	Flow past finite wings	CO5	T1:5.2 R2:10.1
26	Vortex model of the wing and bound vortices	CO5	T1:5.3 R2:11.3
27	Induced drag	CO5	T1:4.6 R2:11.3

Lecture No	Topics to be covered	Course Outcomes	Reference
28	Prandtl's lifting line theory	CO5	T1:5.3 R2:11.3
29	Elliptic wing	CO6	T1:5.3 R2:11.4
30	Influence of taper and twist applied to wings	CO6	T1:5.4
31	Effect of sweep back wings	CO6	T1:5.4
32	Delta wings	CO6	T1:5.6
33	Primary and secondary vortex	CO6	T1:5.6
34	Elements of lifting surface theory	CO6	T1:5.5
35	Source Panel Vortex panel	CO6	T1:5.4
36	Vortex lattice methods	CO6	T1:5.4
37	Flow past non lifting bodies	CO7, CO8	T1:5.4 R3:20.1
38	Method of singularities	CO7, CO8	T1:5.3 R3:20.1
39	Wing-body interference	CO7, CO8	T3:5.2 R3:20.2
40	Effect of propeller on wings and bodies and tail unit	CO7, CO8	T2:7.1 R3:20.3
41	Flow over airplane as a whole	CO7, CO8	T3:6.2 R3:20.4
42	Introduction to boundary layer	CO9, CO10	T3:4.1
43	Laminar and turbulent and transition boundary layer	CO9, CO10	T3:4.2-4.3
44	Boundary layer on flat plate	CO9, CO10	T3:18.2
45	Displacement thickness	CO9, CO10	T3:4.5
46	Momentum thickness	CO9, CO10	T3:4.5
47	Energy thickness	CO9, CO10	T3: 4.5
48	Effect of curvature and Temperature boundary layer	CO9, CO10	T3:4.6

XIX. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S No	Description	Proposed Actions	Relevance with POs
1	Zhukovsky transformation	Seminars	PO 4

Prepared by
Dr. K Maruthupandiyan, Associate Professor **HOD, AE**

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**COMPUTER AIDED DESIGN LABORATORY**				
Course Code	AAEB17				
Program	B.Tech				
Semester	V	AE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Mr. G Rohan, Assistant Professor				

I COURSE OVERVIEW:

This course will also provide the Computer aided design laboratory provides a strong foundations of computer aided designing tool and students will learn the implementation of solid modeling using CATIA. It enables students to master the fundamentals of advanced modeling techniques, sketcher tools, base features, drafting, sheet metal and surface design workbenches. This course focuses on giving the foundations of engineering design and making it very useful for getting the student ready for product manufacturing industry.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB02	II	Engineering Graphics and Design Laboratory

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
CAD Lab	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

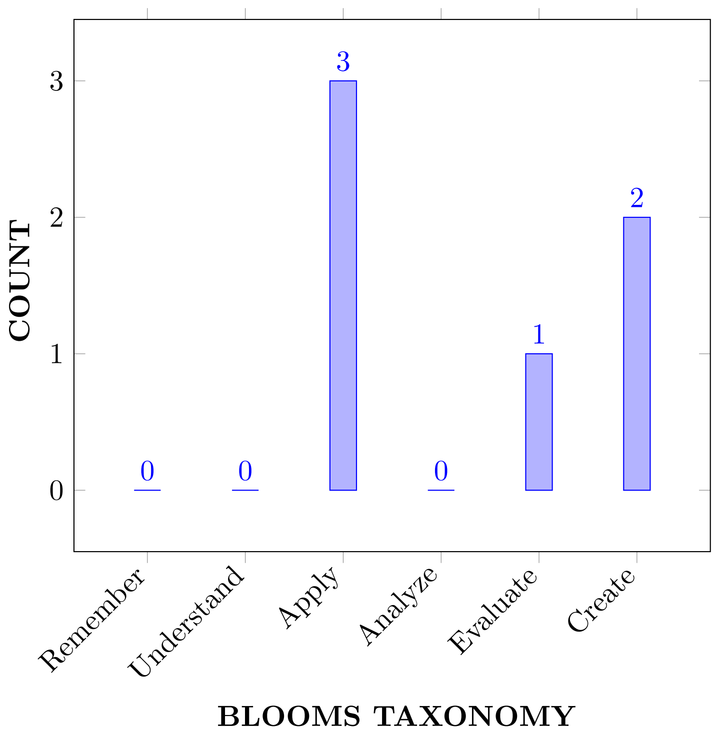
I	Applying principles of isometric and orthographic conversions to create CAD models using CATIA software.
II	Creating profiles and subsequently generating three dimensional entities from the generated profiles.
III	Fundamentals of geometric dimensioning and tolerances and representing those using designing software's.
III	Building various aircraft parts by selecting workbenches appropriate for designing those components.

VII COURSE OUTCOMES:

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

CO 1	**Choose** appropriate tools and profiles for developing the required sketch using the Sketcher workbench.	Apply
CO 2	**Make use of** wireframe elements, surfaces, trim elements and powercopies for constructing the complex surfaces.	Apply
CO 3	**Utilize** different geometric and dimensioning symbols and industry standards for the preparation of technical mechanical drawings.	Apply
CO 4	**Select** appropriate tools available in assembly workbench for creating three-dimensional assemblies incorporating multiple solid models.	Evaluate
CO 5	**Build** components using sketch Based features, perform sheet metal operations and correctly organize the tree for having maximum compatibility for editing or modifying the model.	Create
CO 6	**Develop** amodel from drawing provided and draw conclusions for designing various aircraft components by utilizing different workbenches.	Create

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises

PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Lab Exercises
PO 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 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	Lab Exercises
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Lab Exercises
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	**Justification for mapping (Students will be able to)**	**No. of Key Competencies**
CO 1	PO 1	Use the knowledge of **engineering fundamentals, basic knowledge of engineering drawing(Own Discipline)** and **understanding the design requirements (Own Discipline)** to select appropriate tools for the desired profile.	2

	PO 2	**Identify the options** available that can give competency for creating multiple drawing and modification commands in CATIA and **interpret the positive results** of designs in the sketcher workbench.	2
	PO 5	Identify the suitable **modern software** in order create, select and the apply for engineering drawing skills to obtain accurate part.	3
	PO 9	Understand the engineering drawing by the geometery either by **individual or team work** to design the geometry using CATIA .	3
	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments.	2
	PO 12	Apply the desigining skills learnt in the CATIA lab to identify the method for **real life problems** using suitable Workbench	2
	PSO 3	Outline the drawing methods adopted in **CATIA laboratory** for **designing** of engieneering models **innovative career** path in industry usage.	2
CO 2	PO 1	Use the knowledge of **engineering fundamentals, basic knowledge of engineering drawing** to identify the different tools that are to be used and **obtain the positive results.**	3
	PO 2	**Identify the** tools that are available in CATIA (wireframe, surfaces) for creating aircraft components surfaces models.	2
	PO 5	Identify the suitable **modern software** in order create, select and the apply for desgin of surface bodies.	3
	PO 9	Understand the CATIA design methodologies either by **individual or team work** to design the surface models using CATIA .	3
	PO 10	Make use of **communication skills to write lab related documents** for effective communication with diverse engineering segments.	2
	PO 12	Apply the desigining skills learnt in the CATIA lab to identify the method for **real life problems** using suitable Workbench	2
	PSO 3	Outline the drawing methods adopted in **CATIA laboratory** for **designing** of engieneering models **innovative career** path in industry usage.	2
CO 3	PO 1	Use the knowledge of **engineering fundamentals and basic knowledge of engineering drawing (Own Discipline) to obtain the desired features** in the tool.	3
	PO 5	Identify the suitable **modern software (CATIA)** in order create, select and the apply for desgin of aircraft components using Geometric Dimensions and Tolrances.	3

	PO 9	Understand the appropriate Geometric Dimension and Tolrances methods to draft an engineering design either by **individual or team work** using CATIA .	3
	PO 10	Make use of **communication skills to write lab related documents** for effective communication with diverse engineering segments.	2
	PO 12	Apply the Geometric Dimensions and Tolrances skills learnt in the CATIA lab to identify the method for **real life problems** using suitable Workbench	2
	PSO 3	Outline the drawing methods adopted in **CATIA laboratory** for **designing** of engieneering models **innovative career** path in industry usage.	2
CO 4	PO 1	Apply **engineering fundamentals** and **basic knowledge of engineering drawing** to assemble tools present in CATIA to develop product with joining of individual components.	3
	PO 2	Understand the basic tools available in assembly workbench with **engineering drawing** to enhance the ability to draw conclusions from **the given data provided**	2
	PO 5	Identify the suitable **modern software (CATIA)** in order create, and assemble the designed individual aircraft components for developing the product.	3
	PO 9	Understand the appropriate assembly tools either by **individual or team work** using CATIA for designing a right product.	3
	PO 10	Make use of **communication skills to write lab related documents** for effective communication with diverse engineering segments.	2
	PO 12	Apply the assembly knowledge learnt in the CATIA lab to identify the method for **real life problems** using suitable tools	2
	PSO 3	Outline the drawing methods adopted in **CATIA laboratory** for **designing** of engieneering models **innovative career** path in industry usage.	2
CO 5	PO 1	Use the knowledge of **engineering fundamentals, basic knowledge of engineering drawing** to select appropriate tools that are available in sheet metal for the designing a right egineering model.	2
	PO 5	Identify the suitable **modern software (CATIA)** to perform the sheet metal operation using the given geometry for developing a product.	3
	PO 9	Understand the design of sheet metal tools either by **individual or team work** using CATIA for designing a sheet metal bodies.	3

	PO 10	Make use of **communication skills to write lab related documents** for effective communication with diverse engineering segments.	2
	PO 12	Apply the sheet metal knowledge in the CATIA lab to identify the appropriate solutions for **real life problems**.	2
	PSO 3	Outline the drawing methods adopted in **CATIA laboratory** for **designing** of engieneering models **innovative career** path in industry usage.	2
CO 6	PO 1	Apply **engineering fundamentals, basic knowledge of engineering drawing** and **manufacturing science** to design an aircraft components in the modern design softwares.	2
	PO 5	Identify the suitable **modern software (CATIA)** to design an aircraft components like wing, fuselage, and landing gear using manufacturing process for developing a product.	3
	PO 9	Understand the basic components present in the aircraft while designing either by **individual or team** using CATIA for designing a aircraft structural component.	3
	PO 10	Make use of **communication skills to write lab related documents** for effective communication with diverse engineering segments.	2
	PO 12	Apply the design knowledge on CATIA workbenchs to design the appropriate models for **real life problems**.	2
	PSO 3	Outline the drawing methods adopted in **CATIA laboratory** for **designing** of engieneering models **innovative career** path in industry usage.	2

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

Course Outcomes	Program Outcomes						PSO'S
	PO 1	PO 2	PO 5	PO 9	PO10	PO12	PSO 3
CO 1	2	2	3	3	2	2	2
CO 2	2	2	3	3	2	2	2
CO 3	2	-	3	3	2	2	2
CO 4	2	2	3	3	2	2	2
CO 5	2	-	3	3	2	2	2
CO 6	2	-	3	3	2	2	2

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**SKETCHER**
	Interface, Sketch Tools, View Tool bar, Profile Tool bar, Operation Tool bar, Tools , Constrain tool bar,Transformation Tool bar, User Selection Filter, Standards, Visualizations.
WEEK II	**PART DESIGN**
	Sketch Based Features Dress up Features, Transformation Features, Reference Elements, Measure, Thickness, Boolean Operations.
WEEK III	**SHEET METAL DESIGN**
	Walls, Cutting and Stamping, Bending, Rolled Walls.
WEEK IV	**SURFACE DESIGN**
	Surfacer, Operations, Wireframe, Replication.
WEEK V	**ASSEMBLY**
	Product Structure Tools, Constrains.
WEEK VI	**GD and T**
	Introduction to Geometric Dimensioning and Tolerance, Weld Symbols, GD and T Symbols, Types of Tolerances, Types of views, Roughness Symbols.
WEEK VII	**DRAFTING**
	Views, Annotations, Sheet Background.
WEEK VIII	**DESIGN OF AIRCRAFT WING**
	Design of any two types of Aircraft structures.
WEEK IX	**DESIGN OF FUSELAGE**
	Design of fuselage with internal components.
WEEK X	**DESIGN OF NOSE CONE**
	Design of Nose cone structures.
WEEK XI	**DESIGN OF LANDING GEAR**
	Design of Main landing gear and nose landing gear.
WEEK XII	**REVISION**
	Revision.

REFERENCE BOOKS:

1. http://www.ehu.eus/asignaturasKO/DibujoInd/Manuales/R12.manua.catia.v5.pdf
2. http://www.engr.psu.edu/xinli/edsgn497k/TeaPotAssignment.pdf

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Interface, Sketch Tools, View Tool bar, Profile Tool bar, Operation Tool bar, Tools , Constrain tool bar, Transformation Tool bar, User Selection Filter, Standards, Visualizations.	CO 1	R1: 4.1
2	Sketch Based Features Dress up Features, Transformation Features, Reference Elements, Measure, Thickness, Boolean Operations.	CO 1	R1: 3.1
3	Walls, Cutting and Stamping, Bending, Rolled Walls	CO 1	R1: 3.4
4	Surfacer, Operations, Wireframe, Replication.	CO 2	R2: 3.5
5	Product Structure Tools, Constrains.	CO 2	R2: 4.1
6	Introduction to Geometric Dimensioning and Tolerance, Weld Symbols, GD&T Symbols.	CO 3	R2: 4.2
7	Types of Types of views and product assembly techniques.	CO 4	R2: 4.4
8	Views, Annotations, Sheet Background.	CO 5	R2: 5.1
9	Design of any two types of Aircraft structures.	CO 6	R2: 5.2
10	Design of fuselage with internal components.	CO 6	R1: 5.3
11	Design of Nose cone structures.	CO 6	R1:5.4
12	Design of Main landing gear and nose landing gear.	CO 6	R2:5.5

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design aircraft wings at different sweep angles.
2	Design turbine blades by giving possibility to change the twist angle.
3	Assemble different components of a landing gear by top – down method..

Signature of Course Coordinator **HOD,AE**
Mr. Gooty Rohan, Assistant Professor

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**AIRCRAFT STABILITY AND CONTROL**				
Course Code	AAEB13				
Program	B.Tech				
Semester	V				
Course Type	CORE				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. Yagya Dutta Dwivedi,Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB09	IV	Flight Mechanics

II COURSE OVERVIEW:

Aircraft Stability and Control is the science that investigates the stability and control of aircrafts and all other flying vehicles. From the advent of the first flight by the Wright Brothers, it was observed that flight without knowledge of stability and control was not viable. Since then, several different concepts for controlling aircraft flight have been devised including control surfaces, deformable surfaces, morphing of wings etc. This course introduces some of these concepts and describes their operation, as well as the degree of stability that these devices can provide. Modern aircraft control is ensured through automatic control systems known as autopilot. Their role is to increase safety, facilitate the pilot's task and improve flight qualities. The course will introduce modern aircraft stability and control and discuss some of its objectives and applications.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Aircraft Stability and Control	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE units and each unit carries equal weightage in

terms of marks distribution. The question paper pattern is as follows.
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
85%	Apply
15%	Analyze

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

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

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8th and 17th week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Internal Examination.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 20 multiple choice questions and are be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in the testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quizzes for every course.

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

VI COURSE OBJECTIVES:

The students will try to learn:

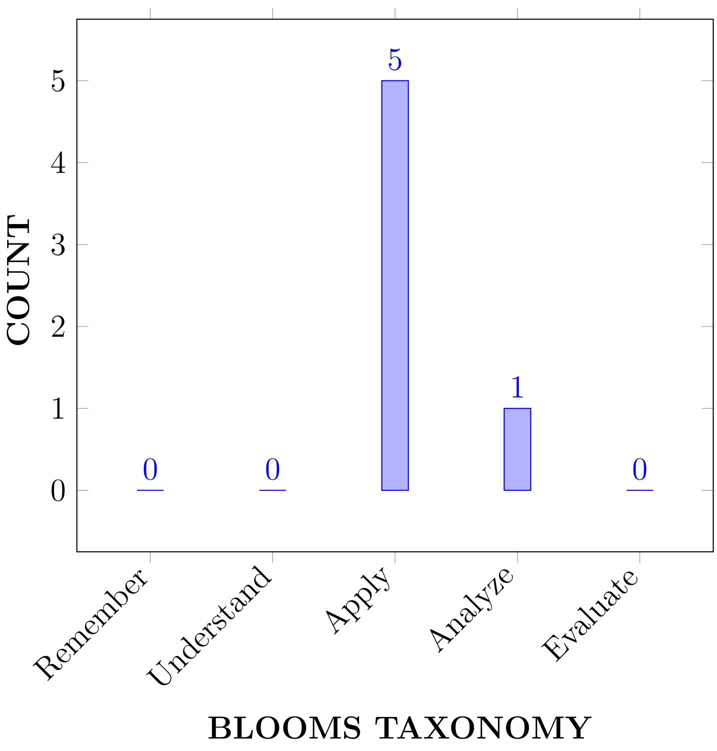
I	The fundamental knowledge on static stability of aircraft in multiple directional motions with their relationship for critical applications in flight vehicles.
II	The aircraft equations of motion to correlate qualitatively with potential applications in aircraft stability in different degrees of freedom (DOF).
III	The methods of optimizing the aircraft equations of motion and its derivatives for aircraft dynamic stability in various flight modes.
IV	The utilization of advances of flight dynamics and control in design and development of modern airplane control systems

VII COURSE OUTCOMES:

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

CO 1	**Identify** the concept of static stability in longitudinal, lateral and directional modes by using mathematical expression for different aircraft stability conditions.	Apply
CO 2	**Solve** Solve the design problems of the airframe components considering the aircraft static stability by using stability criteria equations and plots.	Apply
CO 3	**Make use of** the aircraft equations of motion in 6- degree of freedom and transform one axis to another axis system by using mathematical formulations for understanding the behavior in different flight maneuvers.	Apply
CO 4	**Develop** the procedure to linearization of equations of motion by using perturbation theory for determining aerodynamic derivatives of the airplane.	Apply
CO 5	**Examine** the different types of dynamic modes in longitudinal, lateral and directional motion for the aircraft and their influence on dynamic stability and safety.	Analyze
CO 6	**Apply** the advance theories of flight dynamics in design of modern control airplane control systems for enhancing aircraft performance, Modern control systems and autopilot system.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	**Professional Skills:** Build the prototype of UAVs and aero-foil models for testing by using low speed wind tunnel towards research in the area of experimental aerodynamics.	2	CIE/AAT
PSO 2	**Problem-solving skills:** Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	2	CIE/AAT
PSO 3	**Successful career and Entrepreneurship:**Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	2	CIE/AAT

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recollect (knowledge) the basic concept of static stability and to an extent appreciate (understand) the importance of longitudinal, lateral and directional modes of stability by applying the principles of **mathematics, science and engineering fundamentals.**.	3
CO 2	PO 1	Identify (knowledge) the state of equilibrium, control and trim conditions required (understanding) for an aircraft in static lateral-directional stability **mathematics, science and engineering fundamentals.**	3
	PO 2	Apply and review research literature, and analyze complex engineering problems reaching substantiated conclusions related to lateral stability of aircraft using **first principles of mathematics, natural sciences, and engineering sciences.**	5
	PO 3	Develop the solutions of complex stability problems for an aircraft in static lateral and directional stability for design of the components with consideration of**public health and safety, and cultural, societal and environmental considerations.**	2
	PO 4	Conduct investigation on the neutral point of the system for an aircraft in lateral directional stability to undertake **experiments, analysis and interpretation of the results to provide valid conclusions.**	4
	PSO 2	Apply the given formulations in the effect of horizontal tail on longitudinal static stability for **Problem formulation ,Numerical design and solution development.**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 3	PO 1	Recognizing (knowledge) the contribution of aircraft components which affects static stability of airplane (application) by using **principles of mathematics, sciences and engineering fundamentals.**	3
	PO 2	**Collect the data** from complex **engineering problems** related to design of civil and military aircraft stability characteristics in longitudinal/ lateral direction by **interpreting** the results and **validating** the results obtained through model simulation.	5
	PO 4	Identify (knowledge) the state of equilibrium, control and trim inputs required (understanding) for an aircraft in static longitudinal and lateral directional stability **mathematics, science and engineering fundamentals.**	4
	PSO 3	Identify an exploitable gap in the aerospace market for aircraft stability and control with innovative mechanisms for flight stability and control systems using simulation tools for generating career paths in aerospace industry by **exploitable gap and innovative mechanism.**	2
CO 4	PO 1	Recall(**Knowledge**) the concept of Identify (knowledge) the stick fixed and stick free neutral point and effects on stability by applying the **principles of mathematics, sciences and engineering fundamentals.**	3
	PO 4	Describe (knowledge) the state of equilibrium, control and trim inputs required (understanding) for an aircraft in static longitudinal and lateral directional stability **mathematics, science and engineering fundamentals.**	4
	PSO 2	Apply the given formulations in the effect of horizontal tail on longitudinal static stability for **Problem formulation ,Numerical design and solution development.**	2
CO 5	PO 1	Describe (knowledge) the state of equilibrium, control and trim inputs required (understanding) for an aircraft in static longitudinal and lateral directional stability **mathematics, science and engineering fundamentals.**	3
	PO 2	**I**dentify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions related to lateral stability of aircraft using **first principles of mathematics, natural sciences, and engineering sciences.**	4
	PO 3	Apply (the concept) the state of equilibrium, control and trim inputs required (understanding) for an aircraft in static longitudinal and lateral directional stability **mathematics, science and engineering fundamentals.**	4

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 4	Describe (knowledge) the state of equilibrium, control and trim inputs required (understanding) for an aircraft in static longitudinal and lateral directional stability **mathematics, science and engineering fundamentals.**	4
	PSO 2	Apply the given formulations in the effect of horizontal tail on longitudinal static stability for **Problem formulation ,Numerical design and solution development.**	2
CO 6	PO 1	Apply the dynamic stability criteria for the understanding of the dynamic modes of an airplane by using **mathematics, science and fluid engineering fundamentals.**	3
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions related to lateral stability of aircraft using **first principles of mathematics, natural sciences, and engineering sciences.**	4
	PSO 3	Identify an exploitable gap in the aerospace market for aircraft stability and control with innovative mechanisms for flight stability and control systems using simulation tools for generating career paths in aerospace industry by **exploitable gap and innovative mechanism.**	2

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	100	50	50	67	-	-	-	-	-	-	-	-	-	67	-
CO 3	100	50	-	67	-	-	-	-	-	-	-	-	-	-	67
CO 4	100	-	-	40		-	-	-	-	-	-		-	67	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 5	100	40	50	40	-	-	-	-	-	-	-	-	-	67	-
CO 6	100	40	-	-		-	-	-	-	-	-		-	-	67

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\ \% < C < 60\%$ –Moderate

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Tech talk	-	Concept Video	-	Open Ended Experiments	✓
Seminars	-				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	INTRODUCTION AND LONGITUDINAL STABILITY - I
	Aircraft axes system, definition: equilibrium, stability, controllability and maneuverability. Examples from simple mechanical systems for stability. Longitudinal static stability and dynamic stability for un accelerated flight. Criteria for longitudinal static stability and trim condition. Contribution of Principle components. Equations of equilibrium- stick fixed neutral point, elevator angle required to trim. Definition-static margin. Equations of motion in steady, symmetric pull-up maneuver, elevator effectiveness, elevator hinge moment, neutral point, maneuver point, static margin for stick fixed and stick free conditions, control force and control gradient. Trim tabs and types of trim tabs, aerodynamic and mass balancing of control surfaces, forward and aft most limits of CG.
MODULE II	LATERAL-DIRECTIONAL STATIC STABILITY
	Introduction to lateral-direction stability- aerodynamic forces and moments, aircraft side force due to side slip, aircraft rolling moment due to side slip and aircraft yawing moment due to side slip. Aircraft component contribution on directional static stability, Aircraft component contribution for lateral-directional stability, rudder requirements.
MODULE III	AIRCRAFT EQUATION OF MOTION
	Description of motion of flight vehicle - systems of reference frames - Earth, body, wind, stability axes - relative merits. Euler angles, angles of attack and sideslip– definitions- Earth to body axis transformation, stability axis to body axis transformation. Rotating axis system- expressions for linear and angular moment of rigid body, time derivatives-inertia tensor, components of linear and angular velocities, accelerations. Components of aerodynamic, gravity forces, moments applied on flight vehicle. Equations of motion- longitudinal and lateral-directional. Relation between angular velocity components and Euler angle rates. Determination of velocities of airplane in Earth axis system.
MODULE IV	LINEARIZATION OF EQUATIONS OF MOTION AND AERODYNAMIC FORCES AND MOMENTS DERIVATIVES
	Description of state of motion of vehicle, forces and moments as perturbations over prescribed reference flight condition. Equation of motion in perturbation variables. Assumption of small perturbations, first order approximations- linearization equations of motion. Linearized of force and moment equation, of motion Linearized longitudinal and lateral-directional equations of perturbed motion. Significance of aerodynamic derivatives. Derivatives of axial, normal force components and pitching moment with respect to the velocity, angle of attack, angle of attack rate, pitch rate, elevator angle.
MODULE V	AIRCRAFT DYNAMIC STABILITY
	Principle modes of motion characteristics, mode shapes and significance, time constant, undamped natural frequency and damping ratio- mode shapes- significance. One degree of freedom, two degree of freedom approximations- constant speed (short period), constant angle of attack (long period) approximations- solutions. Determination of longitudinal and lateral stability from coefficients of characteristic equation- stability and lateral stability from coefficients of characteristics equation- stability criteria, Aircraft spin- entry, balance of forces in steady spin

TEXTBOOKS

1. . Yechout, T.R. et al., "Introduction to Aircraft Flight Mechanics", AIAA education Series, 2003, ISBN 1-56347-577-4.
2. Nelson, R.C., "Flight Stability and Automatic Control", 2nd Edn., Tata McGraw Hill, 2007, ISBN 0-07-066110-3.
3. Etkin, B and Reid, L.D., "Dynamics of Flight", 3rd Edn., John Wiley, 1998, ISBN0-47103418-5.

REFERENCE BOOKS:

1. 1. Schmidt, L.V., "Introduction to Aircraft Flight Dynamics", AIAA Education Series, 1st Edition, 1998, ISBN A-56347-226-0.G.
2. 2. McCormick, B.W., "Aerodynamics, Aeronautics, and Flight Mechanics", Wiley India, 2nd Edition, 1995, ISBN 97.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112105171/1
2. https://textofvideo.nptel.iitm.ac.in/112105171/lec1.pdf
3. https://www.fkm.utm.my/ syahruls/3-teaching/2-fluid-II/fluid-II-enote/32-pump-2.pdf
4. https://www.scribd.com/doc/16605891/Fluid-Mechanics

COURSE WEB PAGE:

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Discussion on Outcome Based Education and PO's and CO's		
CONTENT DELIVERY (THEORY)			
2	Introduction Aircraft Stability.	CO 1	T2: 1.1-1.5, T1: 4.1
3	Introduction to Stability and Control	CO 1	T2: 2.1-2.2, R1: 3.1
4	Stability and Trim	CO 1	T2: 2.1-2.2, R1: 3.1
5	Wing Contribution on Static Longitudinal Stability	CO 1	R4: 2.8
6	Basic concepts about airplane static stability	CO 1	T2: 2.3-2.4
7-8	Tail Contribution on Static Longitudinal Stability	CO 2	R4: 2.7.1
8	Neutral Point and Static Margin	CO 1	R4: 2.7.1
9	Neutral Point and Fuselage contribution on Longitudinal Static Stability	CO 1	T2: 3.4
10	Numerical Problems Stability and Tail Contribution	CO 1	T2: 3.4
11	Longitudinal Control	CO 1	T2: 3.3
12	Longitudinal Control and Revision	CO 1	T4: 7.1
13	Control: Elevator	CO 1	R4: 6.3.3

14	CL trim Vs δ_e Trim and Numerical	CO 1	R4: T6.3.2
15	Trim at airplane Cruise, climb and Landing	CO 2	R4: T6.3.2
16	Trim: Maneuver	CO 2	R4: T6.3.2
17	Maneuver Point- Stick Fixed	CO 2	T1 5.5
18	Elevator required at different maneuver with numerical	CO 2	R4: 7.1
19	Directional Stability and Control	CO 2	T2: 5.1
20	Lateral Stability and control	CO 2	T2: 5.2
21	Stick free stability	CO 2	R4: 4.2.1
22	Hinge moment and hinge derivative	CO 2	R4: 4.2.2
23	Aircraft Handling Qualities	CO 2	T1: 5.2
24	Reversible Control: Stick free and Trim Tabs	CO 2	T2: 6.3-6.4
25	Point mass Equations of motion,	CO 3	T2: 5.2
26	Forces and moments	CO 3	T2: 5.2
27	Aircraft Equations of motion	CO 3	T2: 5.2
28	6-DOF, Angular momentum component	CO 3	T2: 13.1-13.2
29	Vector in a Rotating Frame	CO 4	T2: 13.1-13.2.5
30	Euler's Angle	CO 4	T2: 13.2.6
30	Small perturbation theory	CO 5	T2: 13.2.7
31	Perturbed Equations of motion- Longitudinal case	CO 5	T4: 11.1-11.2
32	Perturbed force- Fz	CO 5	T4: 11.2-11.4
33	Longitudinal Dimensional Stability Derivatives	CO 5	T1:11.1, T4:14.1
34	Dynamic stability	CO 5	T1:11.1, T4:14.4
35	Longitudinal Modes	CO 5	T1:11.2-11.4, T4:14.3
36	Pure pitching Motion	CO 5	R4:15.3.1
37	Stability Augmentation system	CO 6	T1:11.1, T4:14.3-14.4
38	Lateral Directional Motion	CO 6	R4:15.4
39	Dynamic stability and its modes	CO 6	R4:15.3.1
40	Characteristics equation and stability criteria with Routh laws	CO 6	T4:14.3-14.4
PROBLEM SOLVING/ CASE STUDIES			
1	Numerical Problems Wing Contribution on Static Stability	CO 1	T2: 1.1-1.5, T1: 4.1
2	Numerical Problems Stability and Tail Contribution	CO 1	T2: 3.4
3	Elevator required at different maneuver with Numerical	CO 1	R4: 2.8
4	Numerical on Maneuvering point	CO 1	R4: T6.3.2
5	Numerical directional, lateral stability	CO 2	R4: T6.3.2
6	CL trim Vs δ_e Trim and Numerical	CO 2	R4: T6.3.2
7	Determination of Neutral point and maneuvering point	CO 2	R4:5.2
8	Revision of Longitudinal static stability,	CO 2	T2:5.2
9	Static stability Numerical- Problem framing	CO 5	T2: 5.2

10	Stick Fixed and Stick free static stability	CO 5	T2: 13.1-13.2.5
11	Problems of Dynamic Stability and revision	CO 6	T4: 11.2-11.4
12	Frequency related Problem and solution	CO 6	T2: 13.2.6
13	Elevator power numerical	CO 3	T4:14.3-14.4
14	Problems of tail/ wing combination	CO 4	T4:14.3-14.4
15	Solving Control problems by finding roots and determination of dynamic stability and performance	CO 6	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Longitudinal static stability , criteria, Effect of components on static stability	CO 1	T2: 1.1-1.5
2	Lateral and directional stability, effect of vertical tail, criteria, Finless aircraft	CO 2	T4:7.3
3	Aircraft axis system, Forces and moments, 6-DOF, Moment of inertia, Eulers angle	CO 3, 4	R4:5.1, T2: 6.3-6.4
4	Velocity derivative, AOA derivative, Mach tuck derivative, Perturbation theory,	CO 5	T1:7.5
5	Dynamic stability, Dynamic modes, natural frequency, Damping ratio, Longitudinal modes, Lateral and direction dynamic modes	CO 6	T1: 12.1
DISCUSSION OF QUESTION BANK			
1	Longitudinal stability and control and its other criteria.	CO 1	T2: 1.1-1.5
2	Lateral and directional stability and control and its other criteria.	CO 2	R4: T6.3.2
3	Aircraft Equations of motion and its application.	CO 3, 4	R4:5.1
4	Aircraft perturbed Equations of motion and application.	CO 5	T4: 11.2-11.4
5	Aircraft dynamic stability and modes.	CO 6	T1:11.2-11.4, T4:14.3

Signature of Course Coordinator **HOD,AE**
Dr. Yagya Dutta Dwivedi, Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION

Course Title	AIRCRAFT PRODUCTION TECHNOLOGY				
Course Code	AAEB18				
Program	B.Tech				
Semester	V	AE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Mr. S Devaraj, Assistant Professor				

I COURSE OVERVIEW:

Production is the process of turning of raw materials or parts into finished goods through the use of conventional tools, human labor and machinery processing. In this course we cover four basic production processes for producing desired shape of a product. These are casting, machining, welding and Production has been an integral part of society for centuries and this looks to continue for as long as humans need products ranging from food and clothes to vehicles and pharmaceuticals.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AMEB01	II	Workshop Manufacturing Practices Laboratory

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
AIRCRAFT PRODUCTION TECHNOLOGY LABORATORY	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	The Importance of manufacturing processes, manufacturing techniques and tools used for production.
II	The information related to thermal, metallurgical aspects during casting and welding for defect free manufacturing components.

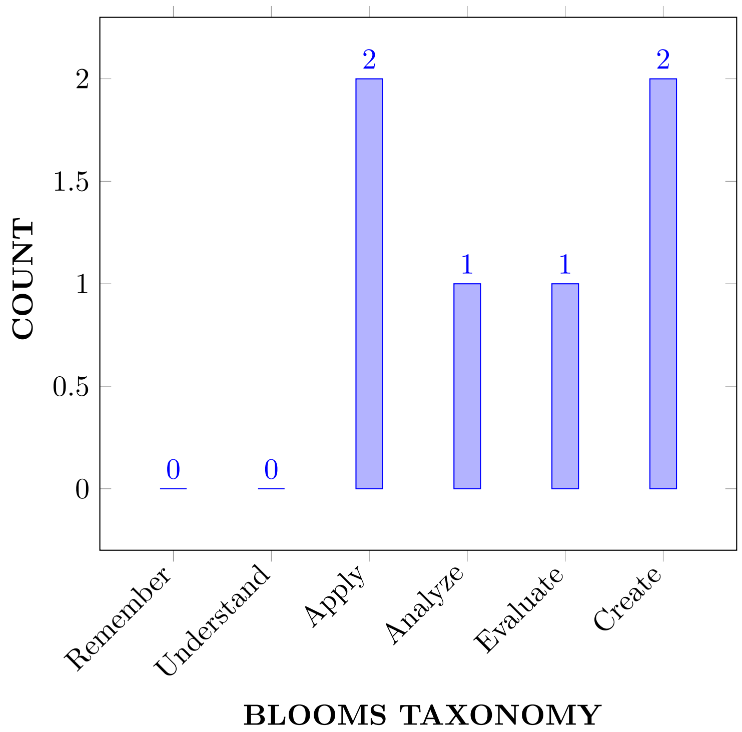
III	The traditional manufacturing processes to application of real time products with economical production.

VII COURSE OUTCOMES:

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

CO 1	**Identify** the steps involved in the process of checking he microstructures of the specimens. .	Apply
CO 2	**Examine** various defects and shortcomings during welding operation such as TIG, MIG and Spot welding for real time applications.	Analyze
CO 3	**Select** the appropriate metals for machining to producing components like shafts and machining components.	Apply
CO 4	**Build** out the molding processes uses sand as raw material and their application in industries for making of machine components.	Evaluate
CO 5	**Design** the gating and riser system needed for casting requirements to achieve defect/error free components.	Create
CO 6	**Choose** the appropriate manufacturing process parameters for effective development of optimized prototype / products.	Create

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program	Strength	Proficiency Assessed by

PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises/CIA/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	3	Lab Exercises/CIA/SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises/CIA/SEE
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Lab Exercises/CIA/SEE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	**Justification for mapping (Students will be able to)**	No. of Key Competencies
CO 1	PO 1	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. **engineering fundamentals.**	2
	PO 2	Understand the given **problem statement and apply data validation techniques to solve** (complex) specific Engineering problems related to making a casting of desired pattern.	3
CO 2	PO 1	Identify (knowledge) in suitable methods involved during welding for error free components using in solving (complex) engineering problems by applying the **principles of Mathematics and engineering fundamentals**	2

	PO 2	Understand the given **problem statement and apply data validation techniques to solve** (complex) specific Engineering problems related to welding in identification of process adoption for the specially develop component.	3
CO 3	PO 1	Recall (**knowledge**) the basic steps involved in design and manufacturing and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals.**	2
	PO 5	Create, select, and apply metal forming techniques, resources, and modern **engineering tools** including prediction and modeling to **complex engineering activities** with an understanding of the limitations..	2
CO 4	PO 1	Recall (knowledge) the basic molding processes uses plastics and identify the importance of system by (apply), implementing complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals.**	2
	PSO 3	Make use of **computational** and **experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 5	PO 1	Identify **(knowledge)** in suitable methods involved in design, casting to achieve error free components using in solving (complex) engineering problems by applying the principles of **mathematics and engineering fundamentals**	2
	PO 5	Design the Riser and Gating system for casting, and **modern engineering tools** including prediction and modeling to **complex engineering activities** with an understanding of the limitations.	2
	PO 9	Design and develop the metal casting Function effectively as an individual, and as a member in **diverse teams**, and in **multidisciplinary settings** for mixing of sand casting effectively in building of product.	2
CO 6	PO 1	Recall **(knowledge)** the basic concepts of manufacturing processes and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals** for better solution.	2
	PO 5	Create, select, and apply appropriate manufacturing process parameters, resources, and modern **engineering tools** including prediction and modeling to **complex engineering activities** with an understanding of the limitations for effective optimization of prototype / products.	2
	PSO 3	Make use of **computational** and **experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2

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

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

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1, PO 2	SEE Exams	PO 1,PO 2,PO 5, PO 9, PSO 3	Seminars	-
Laboratory Practices	PO 1,PO 2, PO 5, PO 9	Student Viva	PO 1, PO 2, PO 5, PO 9	Certification	-
Assignments	PO 5, PO 9, PSO 3				

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**BASIC METALLURGY –I**
	Preparation and study of microstructure of pure materials like Cu and Al. Hardenability of steels by Jominy End Quench test.
WEEK II	**BASIC METALLURGY –II**
	Study of microstructures of non-ferrous alloys. Study of microstructure of heat treated steel.
WEEK III	**LATHE OPERATIONS –I**
	Introduction- lathe machine, plain turning, Step turning and grooving.
WEEK IV	**LATHE OPERATIONS –II**
	Taper turning-compound rest /offset method and Drilling using lathe, External threading-Single start

WEEK V	**SHAPING & SLOTTING**
	Shaping-V-Block and Slotting-Keyways.
WEEK VI	**MILLING**
	Milling-Face milling, End milling and Side milling.
WEEK VII	**GRINDING**
	Grinding-Cylindrical /Surface/Tool and cutter.
WEEK VIII	**DRILLING**
	Drilling, reaming, counter boring, Counter sinking Taping.
WEEK IX	**WELDING PROCESSES I**
	Gas Welding, Brazing and Soldering.
WEEK X	**WELDING PROCESS II**
	Arc welding. Spot welding and TIG welding.
WEEK XI	**BASIC CASTING**
	Preparation of casting with simple patterns.
WEEK XII	**RIVETING ALUMINUM SHEETS**
	Solid and Blind Rivets on aluminum sheets.

TEXTBOOKS

1. Keshu S. C, Ganapathy K. K, —Air craft production technique, Interline Publishing House, Bangalore, 3 rd Edition, 1993
2. R. K. Jain, "Production Technology", Khanna Publishers, 18th Edition, 2013.

REFERENCE BOOKS:

1. Philips Rosenthal, "Principles of Metal Castings", TMH, 2nd Edition, 2001.
2. B. S.Raghuwamshi, "A Course in Workshop Technology", Dhanpat Rai and Sons, 2014.
3. Kalpakjin S, "Manufacturing Engineering and Technology", Pearson Education, 7th edition 2014

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Finding of micro structures for non ferrous metals .	CO1, CO 5	T1:2.1.5 T2:2.3
2	Finding of micro structures for heat treated alloys.	CO1, CO 5	T2:2.1.5 R1:2.6
3	Lathe machine facing and turning operations.	CO 1, CO 4, CO 5, CO 6	T1:2.6 R3:3.6.5
4	Lathe machine taper turning, drilling and threading.	CO 2, CO 6	T2:2.7 R2:2.18
5	Shaping and slotting for cutting key ways and grooves.	CO 2, CO 6	T2:2.22 R3:3.1.1
6	Milling operations like end milling and face milling.	CO 2, CO 6	T1:2.5.1 T2:2.25

7	Surface grinding and cylindrical grinding.	CO 3, CO 6	T2:2.26 R3:2.55
8	Drilling, reaming, counter boring, Counter sinking Taping.	CO 3, CO 6	T2:2.3 R3:2.6
9	Gas Welding, Brazing and Soldering.	CO 3, CO 6	T2:2.3 R1:2.6
10	ARC welding lap and butt joint, Spot welding, TIG welding.	CO 4, CO 6	T1:2.6
11	Molding, melting and casting.	CO 4, CO 6	T2:2.7 R1:2.18
12	Riveting of a Aluminum plate by solid revits	CO 2, CO 6	T2:2.22
13	Riveting of a Aluminum plate by solid revits	CO 1,CO 5, CO 6	T2:2.25

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design and development of gating systems for effective uses of resources for preparation of sand casting.
2	Design of pattern with high grade material to get high precision for error free products.
3	Design and development of force and power requirement for milling processes.
4	Design a compound die with automation for development of prototypes with ease in manufacture.
5	Design and development of riveting operation for semi temporary joints.

Signature of Course Coordinator **HOD,AE**
Mr. S Devaraj, Assistant professor

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

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**ANALYSIS OF AIRCRAFT STRUCTURES**					
Course Code	AAEB14					
Program	B.Tech					
Semester	V	AE				
Course Type	Elective					
Regulation	IARE - R18					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	3	-	3	-	-	
Course Coordinator	Mrs. C Sushmitha, Assistant Professor					

I COURSE OVERVIEW:

This course deals with the fundamental theories of solid mechanics for analyzing the aircraft structures and their limitations to estimate the component life. Composites materials, their importance over metals/alloys, their applications, and their mechanical behavior under loading conditions are discussed in this course. The concepts of open and closed section beams subjected to various loading conditions like torsion and bending which are useful in the design of aircraft sub-structures like wings, fuselages, landing gears, etc are also discussed.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AAEB03	II	Engineering Mechanics
UG	AAEB04	II	Mechanics of Solids
UG	AAEB07	II	Aerospace Structures

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Analysis of Aircraft Structures	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
50 %	Understand
40 %	Apply
30 %	Analyze
0 %	Evaluate
0 %	Create
0%	Remember

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 2), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (Table 3).

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

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

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

Alternative Assessment Tool (AAT)

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

Concept Video	Tech-talk	Open Ended Experiment
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

I	The concepts of estimation of the endurance and failure mechanism of aircraft structural components for safe design.
II	The properties and analysis of composite structures for replacement of aluminum structures with composites for high strength to weight ratio.
III	The mechanism involved in thin walled closed and rectangular section beam subjected to torsion and Shear loads for design of modern aircrafts.
IV	The concepts of Stresses and deflections of various open and closed section aircraft beam structures.

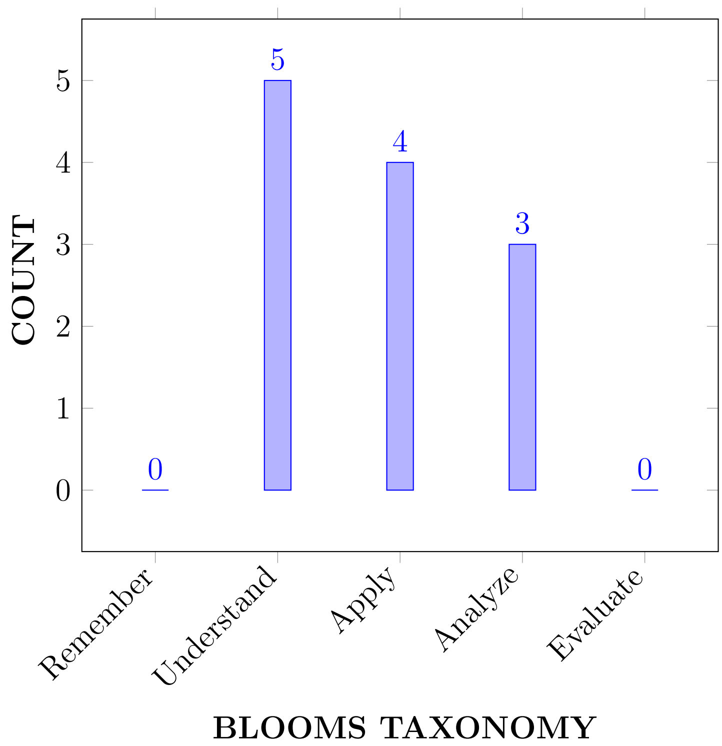
VII COURSE OUTCOMES:

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

CO 1	**Illustrate** the S-N diagram for estimating the endurance limit (failure point) under mean and alternating stresses.	Understand
CO 2	**Analyze** the stresses developed in components like notches, shafts, and methods to reduce stress concentrations for better resistance against failure.	Apply
CO 3	**Apply** the fracture mechanics theories for materials (Ductile, Brittle) subjected to crack(s) for determining the conditions for failure.	Apply
CO 4	**Illustrate** the influence of material thickness, fracture toughness, and stress intensity factors for cracked bodies of various geometries for stress and strain patterns.	Apply
CO 5	**Demonstrate** the crack growth mechanisms for estimating the life of the structural components.	Understand
CO 6	**Summarize** various types of composite materials for deducing the governing constitutive relations for various types of loads and deflections.	Understand

CO 7	**Identify** various types of composite materials used for constructing modern aircraft components and structures to reduce the weight..	Understand
CO 8	**Make use of** the various composite fabrication methods for deflection, shear, and bending and torsion analysis of composite structures.	Understand
CO 9	**Construct** the shear stress distribution in closed section beams subjected to torsion for minimizing stress intensity.	Understand
CO 10	**Analyze** the stresses developed in thin-walled rectangular cross-section beams under torsion load and shear lag analysis to optimize the structure for better load carrying capacities.	Understand
CO 11	**Analyze** the thin walled I- cross sectional Structural member subjected to torsion loads for modern aircraft structural members for better resistance to deflections.	Apply
CO 12	**Extend** the theory of Moment Couple and for better load resistance in aircraft applications.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards	3	Quiz
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	2	Quiz
PSO 3	Make use of design, computational and experimental tools for research and innovation in aerospace technologies and allied streams, to become successful professional, entrepreneurs and desire higher studies.	1	Quiz

3 = High; 2 = Medium; 1 = Low

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

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

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	**Recall** the principals of mathematics to engineering problems for determining High diagram equation used for quantifying the interaction of mean and alternating stresses on the fatigue life of a material using the knowledge of mathematics and science fundamentals.	3
CO 2	PO 1	**Apply** principals of mathematics to the fracture theories for finding out the cracked bodies Strength of ductile materials using the knowledge of mathematics and science fundamentals.	3
	PO 2	**Recognize** the importance of fracture theories for finding out the cracked bodies Strength of ductile materials by applying condition for function to be analytic and the principles of mathematics.	4
CO 3	PO 1	Understand the relationship between magnitude of reversal stress and number of cycles for failure of component by using the mathematical modeling of material concepts.	3

	PO 2	Understand the given **problem statement** and **formulate** the stress for a typical material with the help of (S-N curve)the relationship between the magnitudes and the number of stress, the provided information and data in reaching substantiated conclusions by the **interpretation of results.**	4
CO 4	PO 1	Explain various effects of thickness on fracture toughness and stress intensity factors of cracked bodies of typical geometries for stress analysis by applying the principles of **science and engineering fundamentals.**	3
CO 5	PO 1	Apply the basic conservation laws of science for various phenomena the crack growth mechanisms for estimating the life of the structural components by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals** fracture mechanics.	3
	PO 2	Understand the given **problem statement** and **formulate** the crack growth mechanisms for estimating the life of the structural components for deriving various governing equations of fracture mechanics from the provided **information** and substantiate with the **interpretation of variations in the results.**	4
	PSO3	Make use of **Computational and experimental** tools for creation innovative career paths, to be an entrepreneur and desire for higher studies in the field of structural mechanics.	2
CO 6	PO 1	**Explain** the various types of composite materials and their constitutive relations for effective utilization by applying the principles of **science and engineering fundamentals.**	3
CO 7	PO 1	**Identify** the importance of various types of composite materials for Modern aircraft structural components by applying the principles of science and **engineering fundamentals.**	3
	PSO 3	Make use of Computational and experimental tools for creation innovative career paths, to be an entrepreneur and desire for higher studies in the field of structural mechanics.	2
CO 8	PO 1	**Identify** the various fabrication methods and structural analysis for designing of composite structures, by using the engineering **fundamentals.**	3
	PO 2	**Identify** the various fabrication methods and structural analysis of composite structures for **analyzing the given** engineering problems and **generate the solution.**	4

	PO 3	**Understand the needs** of Aircraft structures, **identify the cost limitations** for the selection of parameters, use creativity in applying the methods of model analyses for **innovative solutions, and understand the economic context** of the model analysis.	4
	PSO 3	Make use of **Computational and experimental** tools for creation innovative career paths, to be an entrepreneur and desire for higher studies in the field of structural mechanics	2
CO 9	PO 1	**Identify** the methods for solving complex engineering problems related to the shear stress distribution at a built-in end of a closed section beam by applying the principles of **mathematics.**	3
	PO 2	**Determine** the shear stress distribution at a built-in end of a closed section beams for **analyzing the given engineering problems and generate the solution.**	4
	PSO 1	**Understand and analyze** the shear stress distribution at a built-in end of a closed section beam subjected to torsion for structural analysis.	3
	PSO 3	Make use of **Computational and experimental** tools for creation innovative career paths, to be an entrepreneur and desire for higher studies in the field of structural mechanics	2
CO 10	PO 2	Application of stress in thin-walled rectangular section beam subjected to torsion and Shear lag analysis and interpretation of the results obtained for given **engineering problems**and **generate the solution.**	4
	PSO 3	Make use of **Computational and experimental** tools for creation innovative career paths, to be an entrepreneur and desire for higher studies in the field of structural mechanics	2
CO 11	PO 2	**Determine** the analysis and design of thin walled I-cross sectional structural member the results obtained for given **engineering problems** and **generate the solution.**	4
	PSO 3	Make use of **Computational and experimental** tools for creation innovative career paths, to be an entrepreneur and desire for higher studies in the field of structural mechanics	2
CO 12	PO 2	Apply the extension of the theory to allow for general systems of loading and Moment Couple for **given engineering problems and generate the solution.**	4
	PO 3	Apply the extension of the theory to allow for general systems of loading and Moment Couple analyses for **innovative solutions, and understand the economic context of the model analysis.**	2

	PSO 3	Make use of **Computational and experimental** tools for creation innovative career paths, to be an entrepreneur and desire for higher studies in the field of structural mechanics	2

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

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

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

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

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

COURSE OUTCOMES	**PROGRAM OUTCOMES**												**PSO'S**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	3	-	-	-	-	-	-		-	-	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	-	-	3
CO 6	3	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 7	3	-	-	-	-	-	-	-	-	-	-	-	3		3
CO 8	3	1	1	-	-	-	-	-	-	-	-	-	-	3	3
CO 9	3	1	-	-	-	-	-	-	-	-	-	-	-	-	3
CO 10	-	1	-	-	-	-	-	-	-	-	-	-	-	-	3
CO 11	-	1	-	-	-	-	-	-	-	-	-	-	-		3
CO 12	-	1	1	-	3		-	-	-	-	2	-	-	-	3
TOTAL	27	8	2	-	6		-	-	-	-	2	3	3	-	21
AVERAGE	3	1	1	-	3		-	-	-	-	1	1	-	-	3

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1,PO 2, PO 3, PO 4	SEE Exams	PO 1,PO 2, PO 3, PO 4	Seminars	-
Laboratory Practices	PO 4	Student Viva	PO 12	Mini project	-
Term Paper	-	-	-	-	-
Assignments	PO 1, PO 2, PO 3, PO 4				

XVI ASSESSMENT METHODOLOGY INDIRECT:

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

XVII SYLLABUS:

MODULE I	FATIGUE OF AIRCRAFT STRUCTURE
	S.N. curves - Endurance limits - Effect of mean stress, Goodman, Gerber and Soderberg relations and diagrams - Notches and stress concentrations - Neuber's stress concentration factors - Plastic stress concentration factors - Notched S.N. curves.
MODULE II	FRACTURE MECHANICS OF AIRCRAFT STRUCTURE
	Strength of cracked bodies - Potential energy and surface energy - Griffith's theory - Irwin - Orwin extension of Griffith's theory to ductile materials - stress analysis of cracked bodies - Effect of thickness on fracture toughness - stress intensity factors for typical geometries. Crack growth mechanisms.
MODULE III	LAMINATED AIRCRAFT COMPOSITE STRUCTURES
	Classification and characteristics of composite materials - Fibrous, Laminated Particulate, Combinations of composite materials, Mechanical Behavior. Basic terminology-laminae, laminates, Manufacture – Initial form of constituent Materials, Layup, Curing, Strength and stiffness Advantages, Cost Advantages, and Weight Advantages. Applications- Military, Civil Aircraft, Space and Automotive. Elastic constants of a simple lamina, Stress–strain relationships for an orthotropic ply(macro- approach), Thin-walled composite beams.
MODULE IV	STRUCTURAL AND LOADING DISCONTINUITIES - CLOSED SECTION BEAMS
	General aspects, Shear stress distribution at a built-in end of a closed section beam, Thin-walled rectangular section beam subjected to torsion, Shear lag.
MODULE V	STRUCTURAL AND LOADING DISCONTINUITIES -OPEN SECTION BEAMS
	I-section beam subjected to torsion, Torsion of an arbitrary section beam, Distributed torque loading, Extension of the theory to allow for general systems of loading, Moment couple (bimoment).

TEXTBOOKS

1. Prasanth Kumar – "Elements of fracture mechanics" – Wheeter publication, 1999.
2. Jones, R.M, Taylor & Francis, —Mechanics of Composite Materials, 2nd Edition, 2010.
3. T. H. G. Megson, "Aircraft Structures for Engineering Students",Butterworth-Heinemann Ltd, 5th Edition, 2012.

REFERENCE BOOKS:

1. Barrois W, Ripely, E.L., "Fatigue of aircraft structure", Pe/gamon press. Oxford, 1983.
2. B. K. Donaldson, —Analysis of Aircraft Structures - An Introduction‖, McGraw Hill, 3rd Edition, 1993.

3. E. H. Bruhn, —Analysis and Design of Flight vehicles Structures‖, Tri-state off set company, USA, 4th Edition, 1965.
4. S. Timoshenko, —Strength of Materials, Vols I and II‖, Princeton D. Von Nostrand Co., Reprint, 1977.
5. J E shigley, C R Mischke, R G Budynas, K J Nisbett, "Mechanical Engineering Design" The McGraw Hill, 8th Edition, 2010.

XVIII COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
1-3	Introduction, S.N. curves - Endurance limits	CO 1, CO 3	T1:1.1-1.6
4	Effect of mean stress	CO 2	T1:1.10
5-6	Goodman, Gerber and Soderberg relations and diagrams	CO 2	T1:1.14
7	Notches and stress concentrations	CO 2	T1:1.14
8	Neuber's stress concentration factors	CO 2	T1:4.1-4.6
9	Plastic stress concentration factors	CO 3	T1:1.17
10	Notched S.N. curves	CO 3	T1:6.1-6.5
11	Strength of cracked bodies	CO 4	T1:6.6-6.9
12	Potential energy and surface energy	CO 4	T1:6.10-6.12
13	Griffith's theory	CO 2	T1:6.10-6.12
14-15	Irwin - Orwin extension of Griffith's theory to ductile materials	CO 4	T1:7.1-7.3
16-17	stress analysis of cracked bodies	CO 4	T1:7.1-7.3
18	Effect of thickness on fracture toughness	CO 5	T1:12.1-12.3
19	stress intensity factors for typical geometries	CO 5	T1:13.1-13.5
20	Crack growth mechanisms	CO 5	T1:7.4-7.5
21	Classification and characteristics of composite materials	CO 6	T1:7.4-7.5
22	Fibrous, Laminated Particulate, Combinations of composite materials,	CO 6	T1:8.1-8.3
23	Mechanical Behaviour	CO 6	T1:8.1-8.3
24	Basic terminology-lamina, laminates, Manufacture	CO 6	T1:8.1-8.3
25	Initial form of constituent Materials,	CO 7	T1:7.1-7.3
26	Layup, Curing, Strength and stiffness Advantages	CO 7	T1:19.1-19.3
27	Cost Advantages and Weight Advantages.	CO 7	T1:19.1-19.3
28	Applications- Military, Civil Aircraft, Space and Automotive	CO 7	T1:19.3
29	Elastic constants of a simple lamina	CO 8	T1:19.3

30	Stress–strain relationships for an orthotropic ply (macro- approach),	CO 8	T1:19.4-19.6
31	Thin-walled composite beams	CO 8	T1:19.6-19.9
32	General aspects	CO 9	T1:19.11
33-35	Shear stress distribution at a built-in end of a closed section beam	CO 9	T1:19.11
36-37	Thin-walled rectangular section beam subjected to torsion	CO 10	T1:19.13-
41-42	I-section beam subjected to torsion	CO 11	T3:1.1-1.6
43-44	Torsion of an arbitrary section beam	CO 11	T3:1.10-
45-46	Distributed torque loading,	CO 11	T3:1.16
46-48	Extension of the theory to allow for general systems of loading	CO 12	T3:2.1-2.2
49-50	Moment couple (bimoment).	CO 12	T3:1.14

Signature of Course Coordinator **HOD,AE**
Ms. C Sushmitha, Assistant Professor

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

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION

Course Title	COMPUTATIONAL STRUCTURAL ANALYSIS LABORATORY				
Course Code	AAEB23				
Program	B.Tech				
Semester	VI	AE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Mr. Gooty Rohan, Assistant Professor				

I COURSE OVERVIEW:

Computational Structural Analysis Laboratory sessions focus on the creation of geometry, meshing (Discretization) and the physics behind the stress strain variation on a continuum. It will also cover the different solvers available in a FEA package and their applications based on the problem type. This course offers a wide range of applications in aircraft structural analysis such as deflection of truss, frames, beams, stress and strain distributions in a plate as well as a solid continuum. Apart from these, it will also address the nonlinear stress problems alongside vibration and flutter analysis.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB04	III	Mechanics of Solids
B.Tech	AAEB07	IV	Aerospace Structures
B.Tech	AAEB19	VI	Finite Element Analysis

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
CSA LAB	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	Make the student familiar with latest computational techniques and software used for structural analysis.
II	. Enable the student to get a feeling of how real-life structures behavior for static and dynamics loads.

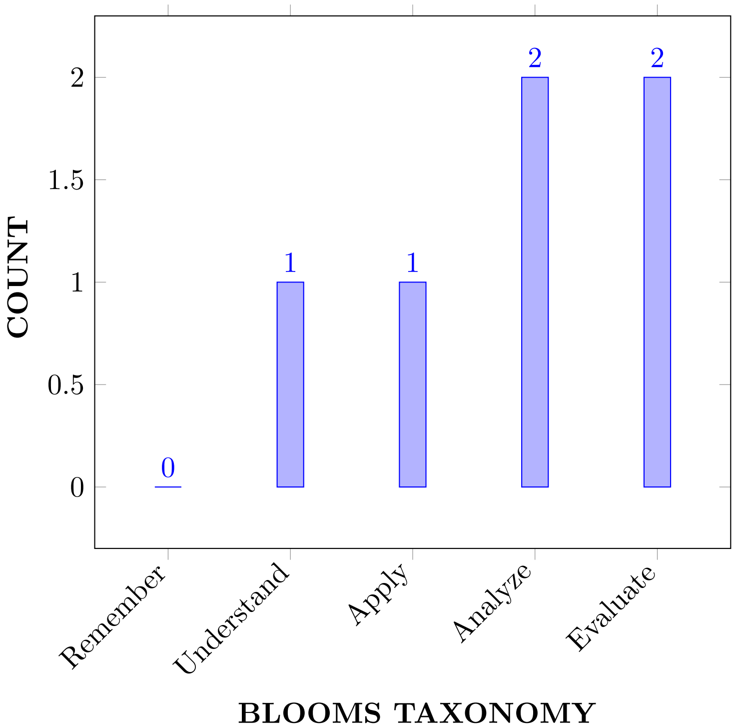
III	. Become familiar with professional and contemporary issues in the design and fabrication.

VII COURSE OUTCOMES:

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

CO 1	**Explain** the computational methods and Softwares that are used in aerospace fields to simulate the complex problems through ANSYS.	Understand
CO 2	**Solve** the parameters like deflections, stress, strain and bending moment by using ANSYS for the linear and non-linear problems that occur in aircraft structural components (beams, bars etc.).	Apply
CO 3	**Calculate** the numerical solution of static structural problems using discretization methods and convergence criteria to minimize the errors.	Analyze
CO 4	**Select** the appropriate heat transfer mechanism using ANSYS thermal workbench for efficient cooling of on board avionics system.	Analyze
CO 5	**Predict** the suitable appropriate results using governing equations for vibrational problems that occur in aircraft structural components (beams, spring-mass system)	Evaluate
CO 6	**Determine** the nature of stress-strain distribution by using appropriate governing equations for an aircraft structural components such as wings, fuselage and landing gear.	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Lab Exercises
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2.5	Lab Exercises
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2.6	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 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	Lab Exercises
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Lab Exercises
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2.8	Lab Exercises

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the basic conservation laws of science for various phenomena of fluid systems and use **mathematical principles** for deriving (complex) fluid flow engineering equations by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals** of fluid mechanics	3
	PO 2	Identify the physical problems with different surfaces and geometries(2D and 3D) for which the temperature distribution and velocity propagation are calculated from numerical methods using principles of **engineering mathematics and sciences.**	2
	PO 3	**Design/development a appropriate solutions** for complex engineering problems using the numerical methods (ANSYS)	3
	PO 4	Make a use of **research methodologies** to investigate the experimental, analytical data with numerical simulational results with ANSYS workbench	1
	PO 5	Identify the suitable **modern software** in order create, select and the apply for complex engineering problems to obtain results.	3
	PO 9	Understand the complex problems either by **individual or team work** to obtain the appropriate results.	3
	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments.	2
	PO 12	Apply the skills learnt in the lab to solve **real life problems** using ANSYS Workbench	3
	PSO 3	Outline the finite element methods adopted in **computational techniques** for **simulation** of fluid thermal systems for **innovative career** path in industry for **modern tool** usage.	3

CO 2	PO 1	Develop the computational programs for governing equations of structural analysis problems from the **mathematical principles** and **engineering fluid thermal sciences**.	3
	PO 2	Identify the principles associated with Static structural problems to **formulate** and calculate the deflection variables **using principles of mathematics, Design and engineering sciences**.	2
	PO 3	**Design/development a appropriate solutions** for complex static structural problems using the ANSYS workbench	3
	PO 4	Make a use of **research methodologies** to investigate the structural problems of the experimental, analytical data with numerical simulational results	3
	PO 5	Identify the suitable **modern software** in order create, select and the apply for linear and non-linear problems to obtain the results.	3
	PO 9	Understand the linear and non-linear structural problems either by **individual or team work** to obtain the approximate results.	3
	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments.	2
	PO 12	Apply the skills learnt in the ANSYS lab to identify the solutions for **real life problems** using suitable Workbench	3
	PSO 3	Outline the finite element methods adopted in **computational techniques** for **simulation** of structural systems for **innovative career** path in industry for **modern tool** usage.	3
CO 3	PO 1	Develop the computational programs for governing equations of structural analysis problems from the **mathematical principles** and **engineering fluid thermal sciences**.	3
	PO 2	Understand the given **problem statement and formulate** complex engineering problems by modeling ,meshing and applying corresponding boundary **information and data** in reaching substantiated conclusions by the **interpretation of results**.	2
	PO 3	**Design/development a appropriate solutions** for complex static structural problems using the ANSYS workbench	2
	PO 4	Make a use of **research methodologies** to investigate the static structural problems of the experimental, analytical data with numerical simulational results	3
	PO 5	Using the suitable **modern software (ANSYS)** in order to identify the solutions for static structural problems using appropriate mesh methods.	3

	PO 9	Understand the approximate results either by **individual or team work** for complex engineering problems through ANSYS.	3
	PO 10	Utilize the **communication skills to write lab related documents** for an effective communication with diverse engineering segments.	2
	PO 12	Apply the skills learnt in the ANSYS lab to identify the solutions for **real life problems** using suitable Workbench	3
	PSO 3	Outline the finite element methods adopted in **computational techniques** for simulation of static-structural systems to **innovative career** path in industry for **modern tool** usage.	2
CO 4	PO 1	Develop the computational programs for governing equations of structural analysis problems from the **mathematical principles** and **engineering fluid thermal sciences**.	3
	PO 2	**Identify** and Understand the given heat transfer problem and **formulate** the appropriate heat flow technique by using **first principles of mathematics** (Partial differential equations).	2
	PO 3	Identify the various techniques that are used to **Design/ develope a numerical solution** for an complex heat transfer problems with ANSYS.	3
	PO 4	Make a use of **research methods** to investigate the complex heat transfer problems to validate the numerical results with experimental data.	3
	PO 5	Using techniques that are in modern tools (ANSYS) to **create, select and apply** the solutions for various heat transfer problems	3
	PO 9	Understand the complex heat transfer problems either by **individual or team work** to identify the solutions through ANSYS.	3
	PO 10	Utilize the **communication skills to write lab related documents** for an effective communication with diverse engineering segments.	2
	PO 12	Apply the skills learnt in the ANSYS lab to identify the solutions for **real life problems** using suitable Workbench	2
	PSO 3	Outline the numerical methods adopted in **computational techniques** for simulation of heat flow systems to **innovative career** path in industry for **modern tool** usage.	3
CO 5	PO 1	Develop the computational programs for governing equations of vibrational analysis problems from the **mathematical principles** and **engineering sciences**.	3
	PO 2	**Identify and formulate** an expression for complex vibrational problems using governing equations with ANSYS.	2

	PO 3	**Design and develop** a solution for vibrational problems that meet the specified needs with appropriate consideration.	2
	PO 4	Make a use of engineering knowledge to **conduct an investigations of complex** vibrational problems using ANSYS.	3
	PO 5	Utilize the **Modern tools (ANSYS)** to create, select and apply the techniques for identifying the solution for complex problems.	3
	PO 9	Resolve the vibrational problems using appropriate techniques and identify the effective solutions either by **individually or team work**.	3
	PO 10	By using the **communication and report writing skills** to develop the effective lab document.	2
	PO 12	Apply the skills learnt in the ANSYS lab to identify the solutions for **real life problems** using suitable Workbench	3
	PSO 3	Make a use of **multi physics and computational methods** for bulding the career paths towards employability and higher studies.	2
CO 6	PO 1	Analyze the different discretization methods for identifying the stress-straindistribution by using **mathematics, science andengineering fundamentals** to minimize the errors.	3
	PO 2	**Identify and formulate** an expression for complex aircraft structural problems using governing equations with ANSYS.	2
	PO 3	**Design and develop** a solution for various stress-strain distribution that are occured in the aircraft structure to meet the specified needs with appropriate consideration.	2
	PO 4	**Knowledge and understanding** the basic processes to **conduct investigations of complex problems** in the design of aircraft structural components to **provide numerical solution** in order to minimize the error.	3
	PO 5	Make use of **modern tools (ANSYS)** to create, select and apply the techniques for identifying the stress-strain values of aircraft components.	3
	PO 9	Resolve the aircraft wing, fuselage, and landing gear stress-strain distribution values using appropriate techniques and identify the effective solutions either by **individually or team work**.	3
	PO 10	By using the **communication and report writing skills** to generate an effective engineering report.	2
	PO 12	Apply the skills learnt in the ANSYS lab to identify the solutions for **real life problems** using suitable Workbench	3
	PSO 3	Make a use of **multi physics and computational methods** for bulding the career paths towards employability and higher studies.	3

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

Course Outcomes	Program Outcomes								PSO'S
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 9	PO10	PO12	PSO 3
CO 1	3	2	3	1	3	3	2	3	3
CO 2	3	2	3	3	3	3	2	3	3
CO 3	3	2	2	3	3	3	2	3	2
CO 4	3	2	3	3	3	3	2	2	3
CO 5	3	2	2	3	3	3	2	3	2
CO 6	3	2	2	3	3	3	2	3	3

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**INTRODUCTION AND BASIC FUNCTIONS**
	Starting up of ANSYS/NASTRAN. Description of user interface.
WEEK II	**STATIC ANALYSIS: TRUSSES AND FRAMES STRUCTURES**
	2D truss structures 3D truss structures
WEEK III	**STATIC ANALYSIS: BEAMS**
	Straight Beams Tapered Beams
WEEK IV	**STATIC ANALYSIS: TWO DIMENSIONAL PROBLEMS**
	2D Structure with various loadings 2D Structure with various materials Plate with a hole

WEEK V	**DYNAMIC ANALYSIS: MODAL AND TRANSIENT ANALYSIS**
	Modal analysis. Transient Response of spring mass system.
WEEK VI	**THERMAL ANALYSIS**
	Bars and Beams. 2D Structures.
WEEK VII	**NONLINEAR ANALYSIS**
	Non-linear behavior (large deflections) Non-linear behavior (materials)
WEEK VIII	**HARMONIC RESPONSE ANALYSIS**
	Random Vibration Analysis of a deep simply-supported beam. Harmonic response of a spring-mass system
WEEK IX	**ANALYSIS OF AIRCRAFT STRUCTURE : WING**
	Static analysis of aircraft wing structure. Modal analysis of aircraft wing structure.
WEEK X	**ANALYSIS OF AIRCRAFT STRUCTURE: FUSELAGE**
	Static analysis of aircraft semi monoque fuselage structure. Modal analysis of aircraft semi monoque fuselage structure.
WEEK XI	**ANALYSIS OF AIRCRAFT STRUCTURE: LANDING GEAR**
	Static analysis of aircraft landing gear. Modal analysis of aircraft landing gear.
WEEK XII	**ANALYSIS OF COMPOSITE STRUCTURES**
	Static analysis of composite bar and beam. Modal analysis of composite plate.

TEXTBOOKS

1. Huei-Huang Lee, —Finite Element Simulations with ANSYS Workbench 16‖, SDC publications, 2 nd Edition, 2016.

2. Anderson, William J —MSC/Nastran: Interactive Training Program‖ Wiley 1 st Edition 2015

REFERENCE BOOKS:

1. Huei-Huang Lee, —Finite Element Simulations with ANSYS Workbench 16‖, SDC publications, 2nd Edition, 2016.

2. Anderson, William J —MSC/Nastran: Interactive Training Program‖ Wiley 1 st Edition 2015.

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Introduction to simulation software.	CO 1	R1: 1.2
2	Introduction to ANSYS.	CO 1	R2: 3.5
3	Verification of Bernoulli's theorem.	CO 1	R1: 3.4
4	Determination of 2-D, 3-D truss structures.	CO 2	R1: 2.2

5	Determine the static-structural analysis.	CO 2	R1: 2.4
6	Determine the Structural analysis of beams under different load condition.	CO 3	R3: 4.5
7	Determine the model analysis of beams and spring-mass system.	CO 3	R3: 4.6
8	Determine the non-linear analysis for large deflections.	CO 4	R2: 5.1
9	Determine the harmonic response analysis of simply-supported beam.	CO 5	R2: 5.2
10	Determine the harmonic response analysis of a spring-mass system	CO 5	R1: 7.1
11	Determine the structural analysis of aircraft wings, fuselage, and landing gear	CO 6	R1:7.2
12	Determine the analysis of composite structures	CO 6	R1:7.3

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Uni-axial tensile** tests of different aircraft grade metals.
2	**Uni-axial compression** tests of different aircraft grade metals.
3	**Three-point bending** tests of a simply supported beam.
4	**Bending** of a cantilever beam.
5	**Harmonic vibration** of a beam

Signature of Course Coordinator **HOD,AE**
Mr. Gooty Rohan, Assistant Professor

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**FINITE ELEMENT ANALYSIS**				
Course Code	AAEB19				
Program	B.Tech				
Semester	VI				
Course Type	CORE				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	1	3		
Course Coordinator	Ms. CH Ragha Leena				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB01	III	Mechanics of Soilds
B.Tech	AAEB07	IV	Aerospace Structures

II COURSE OVERVIEW:

The finite element analysis (FEA) is a numerical method widely used for modeling and analyzing structures. This course introduces the mathematical modeling concepts of the Finite Element Analysis for solving structural, thermal and dynamics problems that are too complicated to be solved by analytical methods.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Finite Element Analysis	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
0 %	Understand
100 %	Apply
0 %	Analyze

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

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

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

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

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

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

VI COURSE OBJECTIVES:
The students will try to learn:

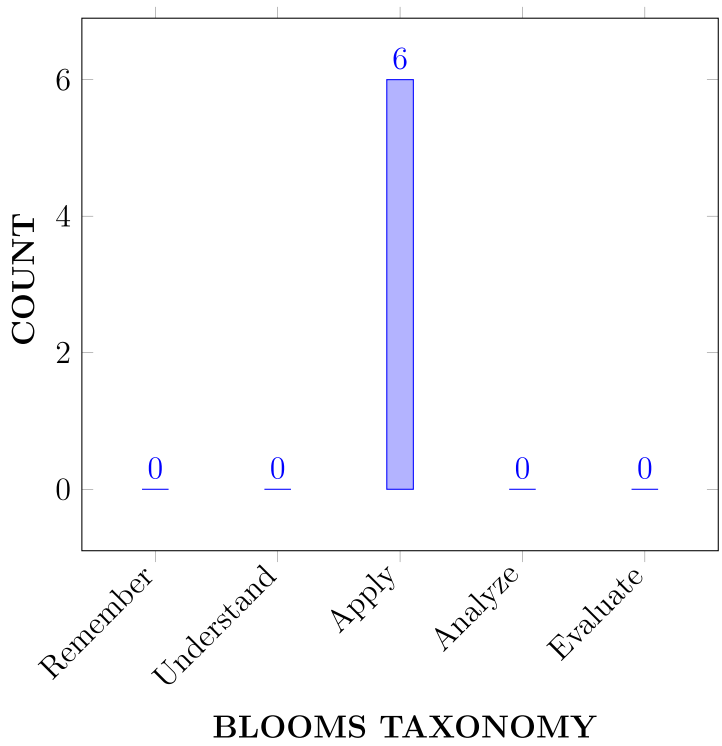
I	The basic concepts of Finite Element methods and its applications to complex engineering problems.
II	The characteristics and selection of different finite elements used in finite element methods.
III	The equilibrium equations and stress-strain relations for different boundary conditions encountered in structural and heat transfer continuum problems.
IV	The application of the FEM technique to dynamic problems and validate the solutions through simulation software for real time applications.

VII COURSE OUTCOMES:

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

CO 1	**Choose** discretization concepts and shape functions of structural members for computing displacements and stresses of the aircraft components.	Apply
CO 2	**Utilize** the shape functions of truss and beam elements for obtaining stiffness matrix and load vector to compute nodal displacement, stresses.	Apply
CO 3	**Identify** the required discreet models of constant strain triangle element for estimating displacement and stress under load conditions.	Apply
CO 4	**Make use of** axi-symmetric modelling concepts to solids of revolution for stress approximation	Apply
CO 5	**Apply** numerical techniques of heat transfer problems to compute the temperature gradients under various thermal boundary conditions	Apply
CO 6	**Develop** the governing equations for the dynamic systems to estimate circular frequency and mode shapes, in correlation with modern tools	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/AAT/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.	2.7	CIE/AAT/SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/AAT/SEE
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	CIE/AAT/SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	3	CIE/AAT/SEE
PO 5	**Modern Tool Usage:** 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/AAT/SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		**Strength**	**Proficiency Assessed by**
PSO 2	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	2.7	CIE/AAT/SEE
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	2	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	**PO'S PSO'S**	**Justification for mapping (Students will be able to)**	**No. of Key competencies matched.**
CO 1	PO 1	Recall the knowledge of **engineering** for explaining the concepts of shape functions of one and two dimensional elements and obtain the stiffness matrix and load vector by using **mathematical and scientific principles**	3
	PO 2	**Identify the given problem and formulate** the global stiffness matrix and load vector for 1D bar element and develop the solution for obtaining displacements, stresses and strains in reaching substantiated conclusions by the **interpretation of results.**	4
CO 2	PO 1	Apply the **engineering knowledge** of shape functions in truss and beam elements for developing stiffness matrix and load vector by using **principles of mathematics and sciences.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	**Identify the problem** of 2D elements and utilize shape functions to **formulate** for obtaining stiffness matrix and load vector for truss and beam elements strains in reaching substantiated conclusions by the **interpretation of results.**	3
CO 3	PO 1	Identify the **mathematical** model for two dimensional CST elements for obtaining stiffness matrix and load vector by using principles of **engineering and sciences.**	3
	PO 2	Understand the given **problem and formulate** it by using finite element method to obtain the shape functions of triangular, axi-symmetric and four noded elements.	2
CO 4	PO 1	Apply the **engineering** concepts of shapes functions to obtain stiffness matrix and load vector for axi-symmetric elements by using the **principles of mathematics and sciences.**	3
	PO 2	**Identify the problem, formulate** stiffness matrix and load vector for axi-symmetric elements **for solution development** in reaching substantiated conclusions by the **interpretation of results.**	4
CO 5	PO 1	Apply the **engineering knowledge** of heat transfer for developing **mathematical models** by using **engineering and sciences.**	3
	PO 2	Recognize the **problem** of heat transfer and formulate thermal stiffness matrix, thermal load vector by applying numerical methods to get the **solution for interpretation of results.**	4
CO 6	PO 1	Develop the **engineering concepts** of dynamic system by using **principles of science and mathematics** to solve structural problems.	3
	PO 2	Recognize the dynamic **problems, formulate** mass matrix for analysing vibrational structures to get the **solution** of Eigen values and Eigen vectors.	3
	PO 5	Make use of **modern tools, create and analyse** mathematical model problems for finding the mechanical and thermal properties of elements.	1
	PSO 3	Use of **computational and experimental tools for creating mathematical model** problems in the fields of mechanical, aeronautical and civil.	2

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

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	60	-	-	-	-	-	-	-	-	-	-	-	75	-
CO 2	100	60	40	-	-	-	-	-	-		60	-	-	60	65
CO 3	100	40	-	45	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	40	40	-	-	-	-	-	-	-	-	-	-	65	65
CO 5	100	60	-	45	-	-	-	-	-	-	-	62	-	-	-
CO 6	100	60	40	-	100	-	-	-	-	60	-	62	-	-	65

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 $< C \leq 40\%$ – Low/ Slight

2 - 40 % $< C < 60\%$ –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 2	3	3	2	-	-	-	-	-	-	3	-	-	-	2	2
CO 3	3	2	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	2	-	-	-	-	-	-	-	-	-	-	3	2
CO 5	3	3	-	2	-	-	-	-	-	-	-	2	-	-	-
CO 6	3	3	2	-	2	-	-	-	-	3	-	2	-	-	2
TOTAL	18	14	6	4	2	-	-	-	-	6	-	4	-	8	6
AVERAGE	3	2.7	2	2	3	-	-	-	-	3	-	2	-	2.7	2

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**INTRODUCTION**
	Introduction to Finite Element Method for solving field problems. Stress and Equilibrium. Boundary conditions. Strain - displacement relations. Stress-strain relations for 2-D and3-D elastic problems. One Dimensional Problems: Finite element modeling coordinates and shape functions. Assembly of Global stiffness matrix and load vector. Finite element equations – Treatment of boundary conditions, Quadratic shape functions.
MODULE II	**ANALYSIS OF TRUSSES AND BEAMS**
	Analysis of Trusses Stiffness matrix for plane Truss Elements, stress calculations and problems Analysis of beams: Element stiffness matrix for two nodes, two degrees of freedom per node beam element and simple problems.
MODULE III	**CONTINUUM ELEMENTS**
	Finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions. Estimation of load Vector, stresses; Finite element modeling of Axisymmetric solids subjected to Axisymmetric loading with triangular elements. Two dimensional four nodded isoparametric elements and problems
MODULE IV	**STEADY STATE HEAT TRANSFER ANALYSIS**
	Steady state Heat Transfer Analysis: 1-D Heat conduction of slab 1D fin elements, 2D heat conduction - analysis of thin plates, Analysis of a uniform shaft subjected to torsion.
MODULE V	**DYNAMIC ANALYSIS**
	Dynamic Analysis: Dynamic equations, lumped and consistent mass matrices, eigen Values and Eigen Vectors for a stepped bar, beam; Finite element, formulation to 3D problems in stress analysis, convergence requirements, mesh generation, techniques such as semi-automatic AND fully automatic use of software such as ANSYS, NISA, NASTRAN.

TEXTBOOKS

1. Tirupathi K. Chandrupatla and Ashok D. Belagundu, "Introduction to Finite Elements in Engineering", Pearson, 4th Edition, 2011.

2. S. Rao, "The Finite Element Methods in Engineering", Elsevier, 4th Edition 2009.

3. J. N. Reddy, "An Introduction to Finite Element Methods", McGraw Hill, 4th Edition 2009.

REFERENCE BOOKS:

1. O.C. Zienkowitz, "The Finite Element Method in Engineering Science", McGraw Hill. 4th Edition, 2009.

2. Robert Cook, "Concepts and Applications of Finite Element Analysis", Wiley, 4th Edition, 2010.

3. S.Md.Jalaludeen, "Introduction of Finite Element Analysis" Anuradha publications, 4th Edition, 2010

WEB REFERENCES:

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

COURSE WEB PAGE:

1. https://lms.iare.ac.in/index?route=course/details&course_id=101

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Course Outcomes, Program Outcomes, Course Objectives		
CONTENT DELIVERY (THEORY)			
2	Introduction to Finite Element Method and steps involved in FEM	CO 1	T1:1.5 R1:2.4
3	Finite Element Method for solving field problems	CO 1	T1:1.5 R1:2.4
4	Stress and Equilibrium. Boundary conditions. Strain - displacement relations	CO 1	T1:1.5 R1:2.4
5	One Dimensional Problems: Finite element modeling coordinates	CO 1	T1:1.5 R1:2.4
6	Shape functions, Linear and Quadratic shape functions.	CO 1	T1:1.5 R1:2.4
7	Assembly of Global stiffness matrix and load vector.	CO 1	T1:1.5 R1:2.4
8	Finite element equations – Treatment of boundary conditions	CO 1	T1:1.5 R1:2.4
9	Analysis of Trusses: Stiffness matrix for plane Truss Elements	CO 2	T1:1.5 R1:2.4
10	Stiffness matrix for space Truss Elements	CO 2	T1:1.5 R1:2.4
11	Assembly of stiffness matrix for plane truss element	CO 2	T1:1.5 R1:2.4
12	Assembly of stiffness matrix for space truss element and solving the FEM equation to get the nodal values	CO 2	T1:1.5 R1:2.4
13	Analysis of beams: Element stiffness matrix for two noded, two degrees of freedom per node beam element	CO 2	T1:1.5 R1:2.4
14	Assembly of stiffness matrix for Beam element and solving the FEM equation to get the nodal slope and deflection	CO 2	T1:1.5 R1:2.4
15	Global stiffness matrix and load vector matrix assembly	CO 2	T1:1.5 R1:2.4
16	analysis of beam by using FEM approach for cantilever and simple supported beams for different loading condition	CO 2	T1:1.5 R1:2.4
17	Finite element modeling of two dimensional stress analysis with linear strain triangles	CO 3	T1:1.5 R1:2.4
18	Finite element modeling of two dimensional stress analysis with constant strain triangles	CO 3	T1:1.5 R1:2.4

S.No	Topics to be covered	CO's	Reference T1: 4.1
19	Treatment of boundary conditions. Estimation of load vector and stresses.	CO 3	T1:1.5 R1:2.4
20	shape functions for triangular element	CO 3	T1:1.5 R1:2.4
21	shape functions for quad element	CO 3	T1:1.5 R1:2.4
22	Two dimensional four noded isoparametric elements, Problems	CO 3	T1:1.5 R1:2.4
23	stress and strain relationship for 2-d element	CO 3	T1:1.5 R1:2.4
24	stress and strain relationship for 3-d element	CO 3	T1:1.5 R1:2.4
25	Finite element modeling of Axi-symmetric solids	CO 4	T1:1.5 R1:2.4
26	Axi-symmetric solids subjected to Axi-symmetric loading with triangular elements	CO 4	T1:1.5 R1:2.4
27	Steady state Heat Transfer Analysis	CO 5	T1:1.5 R1:2.4
28	One dimensional analysis of slab	CO 5	T1:1.5 R1:2.4
29	Fin and two dimensional analysis of thin plate	CO 5	T1:1.5 R1:2.4
30	Assembly of stiffness matrix and load vector matrix for scalar field problems	CO 5	T1:1.5 R1:2.4
31	Anaysis of composite plate for heat transfer due to conduction and convection	CO 5	T1:1.5 R1:2.4
32	Evaluation of Eigen values and Eigen Vectors for a stepped bar	CO 6	T1:1.5 R1:2.4
33	Evaluation of Eigen values and Eigen Vectors for a truss element	CO 6	T2:2.5 R1:2.5
34	formulation of mass matrix model for bar, truss, beam and CST elements	CO 6	T1:2.5 R2:2.6
35	Applying the FEM equation to get the eigen values and eigen vectors for different elements	CO 6	T1:22.7
36	Determine the natural frequencies and mode shapes for different elements	CO 6	T2:6.3 R1:5.3
37	elemental consistent mass matrix and lumped mass matrix model for different elements	CO 6	T1:6.6 R1:5.3.6
38	convergence requirements, mesh generation	CO 6	R3:6
39	introduction to the softwares used to FEM analysis and method of solving the problems	CO 6	T1:7.5 R1:6.3
40	Techniques such as semi automatic and fully automatic use of software such as ANSYS, NISA, NASTRAN	CO 6	T1:8.5 R3:6.8
PROBLEM SOLVING/ CASE STUDIES			
1	Problems on one dimension element to determine the nodal displacements and stress	CO 1	T1:1.5 R1:2.4

S.No	Topics to be covered	CO's	Reference T1: 4.1
2	Problems on ritz methods using minization of potential energy approach	CO 1	T1:1.5 R1:2.4
3	Problems on stepped bar element using elimination and penalty approach	CO 1	T1:1.5 R1:2.4
4	Problems on plane truss element to determine the nodal displacements	CO 2	T1:1.5 R1:2.4
5	Problems on space truss element to determine the nodal displacements	CO 2	T1:1.5 R1:2.4
6	Problems on cantilever beam element for different loading condition	CO 2	T1:1.5 R1:2.4
7	Problems on Simple Supported beam element for different loading condition	CO 2	T1:1.5 R1:2.4
8	Problems on LST and CST element for mechanical and thermal loading	CO 3	T1:1.5 R1:2.4
9	Problems for finding the shape function for Quad element	CO 3	T1:1.5 R1:2.4
10	problems on Axi-symmetric loading with triangular elements	CO 4	T1:1.5 R1:2.4
11	Problems on fin element, thin plate heat transfer for conduction and convection	CO 5	T1:1.5 R1:2.4
12	Problems on plate element conduction and convection	CO 5	T1:1.5 R1:2.4
13	Problems on bar element for finding the natural frequencies, eigen values and eigen vectors	CO 6	T1:1.5 R1:2.4
14	Problems on truss element for finding the natural frequencies, eigen values and eigen vectors	CO 6	T1:1.5 R1:2.4
15	Problems on beam element for finding the natural frequencies, eigen values and eigen vectors	CO 6	T1:1.5 R1:2.4
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	linear and Quadratic shape functions, Stress-strain relations for 2-D and3-D elastic problems	CO 1	T1:1.5 R1:2.4
2	Truss and beam stiffness matrix, matrix assembly	CO 2	T1:1.5 R1:2.4
3	2-D and 3-D stress and strain relationships, LST, CST and axisymmetric analysis methods	CO 3, CO 4	T1:1.5 R1:2.4
4	Heat transfer analysis, conduction and convection matix and assembly	CO 5	T1:1.5 R1:2.4
5	lumped mass model, consistent mass model, natural frequency and meshing techniques	CO 6	T1:1.5 R1:2.4
DISCUSSION OF QUESTION BANK			
1	Stress strain relationships, stiffness matrix for one dimensional bar element, quadratic element	CO 1	R2:2.1
2	Truss elements and problems, Beam element and problems	CO 2	T2:7.3
3	Trinagular elements, Axi-symmetric elements and quadrilateral elements	CO 3, CO 4	R2:5.1

S.No	Topics to be covered	CO's	Reference T1: 4.1
4	Heat transfer analysis-fins, one dimenensioanl and two dimensional problems	CO 5	T1:7.5
5	Dynamic analysis of one dimensional and beam elements	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,AE**

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

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**AIRCRAFT SYSTEMS**				
Course Code	AAEB21				
Program	B.Tech				
Semester	VI	AE			
Course Type	CORE				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	3	-	-
Course Coordinator	Dr.Yagya Dutta Dwivedi, Professor				

I COURSE OVERVIEW:

Aircraft system is required to introduce for operating an aircraft efficiently and safely, their complexity varies with the type of aircraft. This is involved with many subsystems which must meet demanding customer and operational lifecycle. This course comprises into simpler sub-systems such as electrical systems, hydraulic systems, pneumatic and engine control systems etc., that carry out homogeneous functions. The course also aims to provide methods for safety assessment in relation to the design, reliability, safety and certification of aircraft systems.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB03	III	Fluid Mechanics And Hydraulics
B.Tech	AAEB04	III	Basic Electrical and Electronics Engineering

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Aircraft Systems	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
25 %	Understand
40 %	Apply
15 %	Analyze
10 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 2), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (Table 3).

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

Continuous Internal Examination (CIE):

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

Quiz - Online Examination

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

Alternative Assessment Tool (AAT)

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

Concept Video	Tech-talk	Open Ended Experiment
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

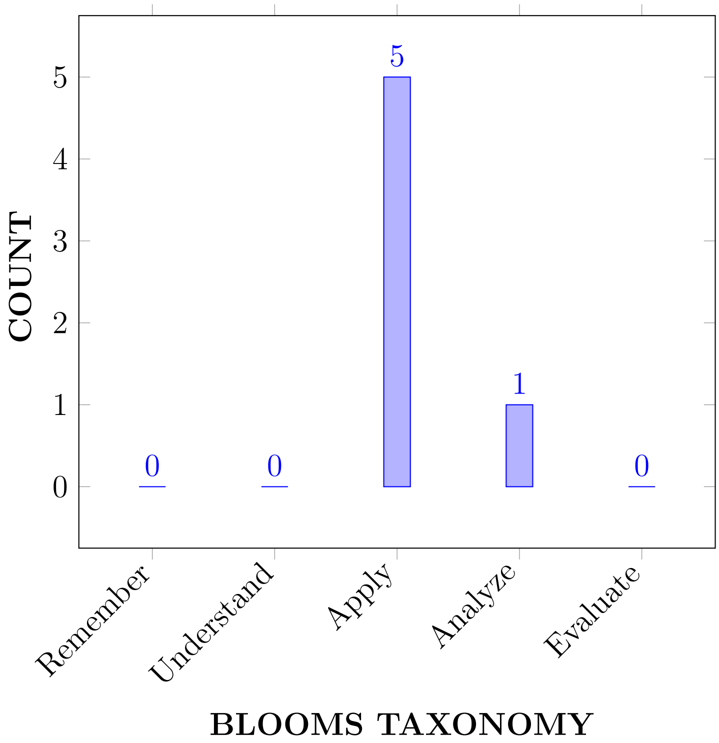
I	The fundamental concepts of aircraft systems its classification and contribution towards the aircraft to fulfill the requirements and missions.
II	Various subsystems : electrical , air conditioning, hydraulic and pneumatic, of an aircraft system.
III	The working principles of engine control and airplane control subsystems of the modern aircraft system.
IV	The design concepts of advanced aircraft systems and controls like fly by wire and autopilots.

VII COURSE OUTCOMES:

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

CO 1	**Develop** the concept of aircraft systems and subsystems like airframe systems, vehicle systems, avionic system and mission systems by using concept of system theory and operating principles.	Apply
CO 2	**Make use of** electrical power generation and air-conditioning systems on the airplane for power distribution and to maintaining pressure and required temperature in the airplane.	Apply
CO 3	**Identify** the principle of operation of hydraulic and pneumatic system with its functions, merits, applications, design requirements and fluid properties for transforming the energy in different hydraulically operated systems.	Apply
CO 4	**Apply** the working principle of aircraft engines its fuel systems and fuel control system	Apply
CO 5	**Develop** the concept of automation in modern flight and engine control systems used in aircraft for safe and sustained flight.	Apply
CO 6	**Examine** the futuristic applications of modern control systems, avionics, and power generation systems used for aerospace applications for enhancing aircraft operations, safety and flight performance.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	1	Research papers / Group discussion / Short term courses

3 = High; 2 = Medium; 1 = Low

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

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

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	**Using basic Scientific principles, Engineering fundamentals** Understanding the concept of aircraft systems and its subsystems	2
	PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for **design and development** of new products.	2
CO 2	PO 1	Understand the mission requirements and performance requirements by **using Scientific principles, Engineering fundamentals**	2
	PO 2	Identify the mission requirements, and performance requirements **using opportunity identification for better design system definition**	2
CO 3	PO 1	Make use of electrical power generation **using Scientific principles and fundamentals in Engineering**.	2

	PO 2	Identify the mission requirements, and performance requirements **using opportunity identification for better design system definition**	2
	PSO 2	**Apply** the concept of electrical power generation and control systems by **Investigating and defining a problem understanding** customer needs and identify and use creativity for Power distribution of primary and secondary control system	2
CO 4	PO 1	Understanding the knowledge of the basic air cycle systems and vapor cycle systems by **using scientific principles and engineering fundamentals**.	1
	PO 2	Identify the mission requirements, and performance requirements **using opportunity identification for better design system definition**	1
	PSO 2	**Focus** on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for **design and development** of new products.	2
CO 5	PO 1	**Understanding** the Principal components of Hydraulic system by **using scientific principles and engineering fundamentals**	2
	PO 2	**Understand** the principal operation of hydraulic system its function, merits, application, design requirements and Hydraulic fluid properties using **Problem identification and system defining by using experimental design**.	1
CO 6	PO 1	Understanding the working principles of pneumatic system and break management system in landing gear by using using **scientific principles and engineering fundamentals**.	2
	PO 2	Application of **Problem identification and system definition** in break management system for quick and easy operation using **experimental design**	1
	PSO 2	**Focus** on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for **design and development** of new products.	2

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

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

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

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

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	67	-	-	-	-	-	-	-	-	-	-		-	34	-
CO 2	67	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	67	20	-	-	-	-	-	-	-	-	-	-	-	67	-
CO 4	34	10	-	-	-	-	-	-	-	-	-		-	67	-
CO 5	67	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	67	10	-	-	-	-	-	-	-	-	-		-	67	-

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

2 - 40 % <C < 60% –Moderate

1-5 <C$\leq$ 40% – Low/ Slight

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

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-		-	3	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 3	3	-	3	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	1	-	3	-	-	-	-	-	-	-	-		-	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-		-	-	-
TOTAL	30	10	6	-	-	-	-	-	-	-	-	-	-	18	-
AVERAGE	3	1.43	3	-	-	-	-	-	-	-	-	-	-	1.8	-

XV ASSESSMENT METHODOLOGY DIRECT:

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

XVI ASSESSMENT METHODOLOGY INDIRECT:

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

XVII SYLLABUS:

MODULE I	**INTRODUCTION TO AIRCRAFT SYSTEMS**
	System concepts, sub-systems; Generic system definition, inputs, outputs, feedback, external influence. Aircraft systems- airframe systems, vehicle systems, avionics systems, mission systems and their sub-systems; Specification of requirements, mission requirements, performance requirements.
MODULE II	**ELECTRICAL SYSTEMS AND AIR CONDITIONING, PRESSURIZING SYSTEMS**
	Electrical loads in aircraft. Electrical power generation and control- DC, AC- types. Power distribution- primary, secondary. Power conversion and energy storage; Load protection; Electrical load management systems, 270 V DC systems; Basic air cycle systems; Vapor cycle systems, boost-strap air cycle system; Evaporative Vapor cycle systems; Evaporative air cycle systems; Oxygen systems; deicing and anti-icing systems.
MODULE III	**HYDRAULIC SYSTEMS AND PNEUMATIC SYSTEMS**
	Hydraulic systems: function, merits, application, system loads, design requirements; Principal components; Hydraulic fluid: required properties; Hydraulic piping, pumps, reservoir, accumulator; Pneumatic systems: Advantages;- Working principles ; Typical air pressure system ; Brake system; Typical pneumatic power system ; Components, landing gear systems ; Landing gear and brake management systems.
MODULE IV	**ENGINE CONTROL AND FUEL SYSTEMS**
	Principle of operation of aircraft gas turbine engines; Engine - airframe interfaces; Control of fuel flow, air flow, Limited authority control systems, full authority control systems- examples; Power off takes- need, types; Fuel systems- characteristics, components, operating modes; Fuel tank safety- fuel inserting system.

MODULE V	**AIRPLANE CONTROL SYSTEMS**
	Flight control systems- primary and secondary flight control conventional systems; Power assisted and fully powered flight controls ; Power actuated systems; Engine control systems; Push pull rod system, flexible push full rod system; Control linkages, actuation- types, description and redundancy. Components; Modern control systems; Digital fly by wire systems, control more laws, implementation; Auto pilot system.

TEXTBOOKS

1. Moir, I. and Sea bridge, A, Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration‖, John Wiley, 3rd Edition 2008.
2. Moir, I. and Sea bridge, A, Design and Development of Aircraft Systems- An Introduction‖, AIAA Education Series‖, AIAA, 2004.

REFERENCE BOOKS:

1. 1. Pallett, E.H.J., Aircraft Instruments and Integrated Systems‖, Longman Scientific and Technical 10th Edition, 1992.
2. Harris, D, Flight Instruments and Automatic Flight Control Systems‖, 6th Edition, 2004.
3. 3. Bolton, W., Pneumatic and Hydraulic Systems‖, Butterworth-Heinemann.

XVIII COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Course discrption		
CONTENT DELIVERY (THEORY)			
1	System concepts, sub-systemss	CO1	T1:1-1-1
2	Generic system definition, inputs, outputs	CO1	T1:3-1-1 T2:5.4
3	Feedback, external influence. Aircraft systems- airframe systems	CO1	T1:1.2
4	Vehicle systems, avionics systems	CO1	T1:1.2
5	Mission systems and their sub-systems	CO1	T1:1.1
6	Need for stable, effective (responsive), robust control system	CO1	T1:1.1
7	Specification of requirements, mission requirements, performance requirements	CO2	T1:4-1
8	Examples from diverse fields for modeling of dynamical system	CO2	T1:4-2-T1:4-5
9	Electrical loads in aircraft. Electrical power generation and control	CO2	T1:2-3

10	Electrical loads in aircraft. AC and DC power generation and control	CO2	T1:2-7
11	DC, AC- types in electric power generation	CO2	T1:5-1- T1:5-3
12	Power distribution- primary, secondary	CO2	T1:2-7 T1:5-2 T1:5-3
13	Power conversion and energy storage	CO2	T1:5-5 T1:5-6
14	Electrical load management systems	CO3	T1:2-7
15	Basic air cycle systems; Vapor cycle systems, boost-strap air cycle system	CO3	T1:2-3
16	Vapor cycle systems, boost-strap air cycle system	CO4	T1:2-4
17	Evaporative Vapor cycle systems;	CO3	T1:2-2
18	Evaporative air cycle systems	CO3	T1:2-3- T1:2-7
19	Oxygen systems; deicing and anti-icing systems	CO3	T1:2-2
20	Relation of transfer functions to impulse response. Partial fraction decomposition of transfer functions- significance	CO4	T1:2-7 T1:2-5
21	Hydraulic systems: function, merits, application, system loads, design requirements	CO4	T:5-4
22	Principal components; Hydraulic fluid	CO4	T1:3-1-3
23	: Required properties;	CO5	T1:4-6
24	Hydraulic piping, pumps, r	CO5	T1:2-7
25	reservoir, accumulators	CO5	T1:4-1- T1:4-8
26	Pneumatic systems principle	CO5	T1:4-1- T1:4-8
27	Advantages;- Working principles of pneumatic system	CO5	T1:5
28	Typical air pressure system	CO5	T1:5
29	; Brake system	CO2	T1:2-2
30	Typical pneumatic power system ; Components	CO3	T1:2-3
31	Landing gear systems; Landing gear and brake management systems	CO5	T1:2-4
32	Principle of operation of aircraft gas turbine engines	CO6	T2:3.1- 3.8 R2:3.2
33	Control surface actuators-review	CO5	T2:4.1- 4.2 R2:3.2
34	Engine airframe interfaces; Control of fuel flow, air flow, Limited authority control systems	CO 6	T2:4.2- 4.3 R2:3.2

35	Full authority control systems- examples; power off takes-need	CO 3	T2:4.6
36	Types; Fuel systems- characteristics, components, operating modes	CO 3	T2:4.4-4.5 R2:3.2
37	Fuel tank safety- fuel inserting system	CO 3	T2:4.4-4.5 R2:3.2
38	Flight control systems- primary and secondary flight control conventional systems; Power assisted and fully powered flight controls	CO 3	T2:4.7
39	Power actuated systems; Engine control systems; Push pull rod system, flexible push full rod system; Control linkages	CO 6	T2:3.1-3.3 R1:5.2
40	Actuation- types, description and redundancy	CO 3	T2:6.1 R1:5.2
PROBLEM SOLVING/ CASE STUDIES			
1	Development of aircraft systems	CO1	T2:6.2 R15:2
2	Aircraft mission systems case study on modern system	CO 1	T2:6.3 R15:5
3	Control augmentation systems- Full authority fly-by-wire.	CO 2	T2:4.5 R2:3.6
4	Fly by wire system	CO 6	T2:6.1
5	Case study on aircraft DC system	CO 2	T2:4.6 T2:5.4
6	Case study on 270 V DC power supply. Why?.	CO3	T1:2-2
7	Aircraft Hydraulic system	CO3	T1:2-3-T1:2-7
8	Frequency and damping ratio of dominant poles.	CO2	T1:2-2
9	Relation of transfer functions to impulse response.	CO4	T1:2-7 T1:2-5
10	case study on error constants- overall system stability.	CO2	T:5-4
11	Digital fly by wire systems, control laws, implementation; Auto pilot system	CO5	T1:3-1-3
12	Case study on -Components; Modern control systems	CO5	T1:4-6
13	Power actuated systems; Engine control systems; Push pull rod system, flexible push full rod system; Control linkages	CO6	T1:4-1
14	Flight control systems- primary and secondary flight control conventional systems; Power assisted and fully powered flight controls	CO6	T1:4-2-T1:4-5
15	Flyby Wire in its development	CO6	T1:4-2-T1:4-5

DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	INTRODUCTION TO AIRCRAFT SYSTEMS	CO 1	T2:6.2 R15:2
2	ELECTRICAL SYSTEMS AND AIR CONDITIONING, PRESSURIZING SYSTEMS	CO2	T2:6.3 R15:5
3	HYDRAULIC SYSTEMS AND PNEUMATIC SYSTEMS.	CO 3	T2:4.5 R2:3.6
4	ENGINE CONTROL AND FUEL SYSTEMS	CO5	T2:6.1
5	AIRPLANE CONTROL SYSTEMS	CO6	T2:4.6 T2:5.4
DISCUSSION OF QUESTION BANK			
1	System concepts, sub-systems	CO 1	R4:2.1
2	Vehicle systems of aircraft	CO 3	T4:7.3
3	Flight control system	CO 4	R4:5.1
4	Engine control systems	CO 5	T1:7.5
5	Airplane control system	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,AE**

IARE

EDUCATION FOR LIBERATION

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Aeronanutical Engineering**				
Course Title	**Computational Aerodynamics**				
Course Code	AAEB20				
Program	B.Tech				
Semester	VI				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	4	-	4	-	-
Course Coordinator	Mr. Athota Rathan Babu, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAE003	III	Fluid Mechanics and Hydraulics
B.Tech	AAE004	IV	Low Speed Aerodynamics
B.Tech	AAE008	V	High Speed Aerodynamics

II COURSE OVERVIEW:

Computational aerodynamics is the study of computational analysis on aerodynamic flow bodies. This course deals with the basic aspects of Computational Fluid Dynamics, emphasizing on the governing equations of fluid dynamics and their numerical discretization techniques using finite volume and finite difference methods. The course also discusses the methods of grid generation techniques for both structured and unstructured grid in 2D as well as 3D. It describes the mathematical behavior of the different classes of partial differential equations, this deal with pressure based solvers for incompressible viscous flow.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Computational Aerodynamics	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
17 %	Understand
83 %	Apply
0 %	Analyze
0 %	Evaluate
0 %	Create

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

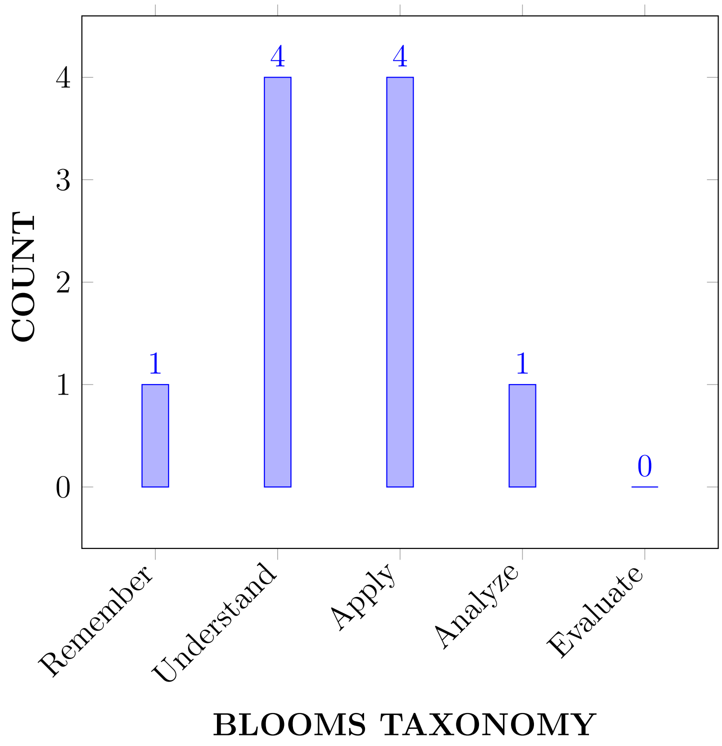
I	The concepts of grid generation techniques for simple and complex domains to model fluid flow problems.
II	The aspects of numerical discretization techniques such as finite volume and finite difference methods.
III	The mathematical modeling of different classes of partial differential equations to show their impact on computational fluid dynamics.
IV	The characteristics of different turbulence models and numerical schemes for estimating the criteria of stability, convergence, and error of fluid flow problem.

VII COURSE OUTCOMES:

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

CO 1	**Summarize** the concepts of computational fluid dynamics and its applications in industries as a tool for fluid analysis.	Understand
CO 2	**Choose** the type of flow from the finite control volume and infinitesimal small fluid element for the fluid flow analysis.	Apply
CO 3	**Select** the quasi linear partial differential equation for estimating the behavior in computational fluid dynamics.	Apply
CO 4	**Identify** CFD techniques for relevant partial differential equations for getting analytical solutions for fluid flow problems.	Apply
CO 5	**Make use of** finite difference approach for numerical formulations based on fluid mechanics and heat transfer concepts for getting the solutions of fluid flow problems.	Apply
CO 6	**Utilize** the grid generation and transformation techniques in implementation of finite difference and finite volume methods in solving complex fluid and aerodynamic problems.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	CIE/Quiz/AAT
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	2	CIE/Quiz/AAT
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	3	CIE/Quiz/AAT
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical including air traffic controls standards.	2	Research papers/ Group discussion/ Short term courses
PSO 3	Make use of design, computational and experimental tools for research and innovation in aerospace technologies and allied streams, to become successful professionals, entrepreneurs and desire higher studies.	2	Research papers/ Group discussion/ Short term courses

3 = High; 2 = Medium; 1 = Low

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

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Summarize the history, basics of computational fluid dynamics (Knowledge) and its importance in solving complex **engineering problems** by applying partial differentials **mathematics** and fundamentals of engineering and fluid sciences.	3
	PO 2	**Select the type of flow based on control volume** analysis by basic partial differentials (mathematics) and fluid sciences.	2
	PO 3	**Identify appropriate finite difference methods for numerical formulations** from the fundamentals of mathematics and engineering fluid thermal sciences.	3
	PO 4	Understand the given fluid flow problem and formulate the appropriate CFD technique **by using first principles of mathematics (Partial differential equations) to get analytical solutions** in order to validate results.	2
	PO 7	Understand the customer requirement, identify the proper finite volume method for **complex thermal systems used in various applications**.	2
CO 2	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** and derive the governing equations under different conditions	3
	PO 2	**Identify and Understand** the given fluid flow problem and formulate the appropriate CFD technique by using first principles of mathematics (Partial differential equations) to get analytical solutions in order to validate results.	2
	PO 3	**Formulate the problem statement and identify** the suitable finite difference method to obtain substantiated conclusions by the interpretation of results.	3
	PO 6	**Understand the customer requirement, identify** the proper finite volume method for complex thermal systems used in various applications.	2
	PO 10	Identify the available partial differential equations (analytical methods) for **engineering fluid flow problems and apply** computer software (CFD) to provide solutions by analyzing the processes.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 1	**Illustrate the quasi linear partial differential equation** to physical systems in design of fluid thermal systems to provide solutions in interdisciplinary applications.	2
CO 3	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals to illustrate the quasi linear partial differential equations **using principles of mathematics, science, and engineering fundamentals.**	3
	PO 3	Analyze the performance parameters of CFD techniques and various schemes used on CFD models using **first principles of Mathematics and engineering sciences.**	3
	PO 4	Identify the available partial differential equations (analytical methods) for engineering fluid flow problems and apply computer software (CFD) to provide solutions by analyzing the processes.	2
	PO 7	Select the necessary discretization methods to analyse the stability of fluid system in the aspect of design the problems experimentally and numerically to recognize the significance of them in solving various engineering problems and creating solutions for thermal systems.	2
	PO 12	Apply appropriate finite volume technique to solve the complex thermal problems.	2
	PSO 3	Build various methods of grid generation techniques for Designability of physical systems into mathematical formulations with Sustainable designs	2
CO 4	PO 1	**Analyse** the different discretization methods for solving thermal problems by using **engineering fundamentals in fluid sciences using mathematical equations** (partial differential equations) to minimise the errors.	3
	PO 2	**Identify, define the necessary discretization** methods to analyse the stability of fluid system in the aspect of design the problems experimentally and numerically to recognize the significance of them in solving various engineering problems and creating solutions for thermal systems.	2
	PO 4	Knowledge and understanding the basic processes to **conduct investigations of complex problems in the design, analysis** to provide numerical solution in order to minimise the error.	2
	PSO 1	**Identify** the available partial differential equations for engineering fluid flow problems and apply computer software (CFD) to provide **solutions by analyzing the processes**.	2
CO 5	PO 1	Select appropriate finite difference methods for numerical formulations from the fundamentals of mathematics and engineering **fluid thermal sciences.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 3	**Understand** the given fluid flow problem and formulate the appropriate CFD technique by using first principles of mathematics (Partial differential equations) and **approriate numerical techniques to get solutions and validate results.**	3
	PO 5	**Select an appropriate technique of finite volume methods** to solve the fluid flow of real world problems.	2
	PO 12	**Build up (Apply) the skills** in the actual implementation of CFD methods in industry trends based on advanced engineering concepts.	2
	PSO 1	Analyze the performance parameters of CFD techniques and various schemes used on CFD models using **first principles of Mathematics and engineering sciences.**	2
	PSO 3	**Make use of computational techniques** and simulation methods for the analysis of fluid problems in the career path of **modern engineering start up industries**.	2
CO 6	PO 1	Distinguish various methods of grid generation techniques in the design of complex problems by using **fundamental knowledge of fluid science and engineering** to evolve relationships using partial derivative **mathematical functions**	3
	PO 2	**Understand the customer requirement, identify the** proper finite volume method for complex thermal systems used in various applications	2
	PO 3	**Build up the appropriate techniques** for prediction and modelling the fluid flow and heat transfer problems by using modern engineering tools and simulation techniques with an understanding of limitations.	3
	PO 4	Recognize (Knowledge) the characteristics of various fluid flow processes, understand the corresponding the context of **engineering knowledge related to different methods** of CFD and analyse the basic parameters influencing the flow by incorporating commercial CFD codes.	2
	PO 10	**Apply the skills in the actual implementation** of CFD methods in advanced industry trends based on engineering concepts.	3
	PSO 1	Illustrate the quasi linear partial differential equation to design tools for scale down models and **technologies for development of high efficiency**.	2

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\ \% < C < 60\%$ –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	2	2	-	-	2	-	-	-	-		-	-	-
CO 2	3	2	2	-	-	2	-	-	-	3	-	-	2	-	-
CO 3	3	-	3	2	-	-	2	-	-	-	-	2	-	-	2
CO 4	3	2	-	2	-	-	-	-	-	-	-		2	-	-
CO 5	3	-	3	-	2	-	-	-	-	-	-	2	2	-	2
CO 6	3	2	3	2	-	-	-	-	-	3	-		2	-	-
TOTAL	18	8	13	8	2	2	4	-	-	6	-	4	8	-	4
AVERAGE	3	2	2.6	2	2	2	2	-	-	3	-	2	2	-	2

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION**
	Need of computational fluid dynamics, philosophy of CFD, CFD as a research tool as a design tool, applications in various branches of engineering, models of fluid flow finite control volume, infinitesimal fluid element, substantial derivative physical meaning of divergence of velocity, derivation of continuity, momentum and energy equations, physical boundary conditions significance of conservation and non-conservation forms and their implication on CFD applications strong and weak conservation forms shock capturing and shock fitting approaches.
MODULE II	**MATHEMATICAL BEHAVIOR OF PARTIAL DIFFERENTIAL EQUATIONS AND THEIR IMPACT ON COMPUTATIONAL AERODYNAMICS**
	Classification of quasi-linear partial differential equations by Cramer‘s rule and Eigen value method, general behavior of different classes of partial differential equations and their importance in understanding physical and CFD aspects of aerodynamic problems at different Mach numbers involving hyperbolic, parabolic and elliptic equations: domain of dependence and range of influence for hyperbolic equations, well-posed problems.
MODULE III	**BASIC ASPECTS OF DISCRETIZATION**
	Introduction to finite difference: finite difference approximation for first order, second order and mixed derivatives, explicit and implicit approaches, truncation and round-off errors, consistency, stability, accuracy, convergence, efficiency of numerical solutions. Von Neumann stability analysis, physical significance of CFL stability condition. Need for grid generation, structured grids artesian grids, stretched (compressed) grids, body fitted structured grids, H-mesh, C-mesh, O-mesh, I-mesh, multi-block grids, C-H mesh, H-O-H mesh, overset grids, adaptive grids, unstructured grids: triangular, tetrahedral cells, hybrid grids, quadrilateral, hexahedral cells.

MODULE IV	**CFD TECHNIQUES**
	Lax-Wendroff technique, MacCormack's technique, Crank Nicholson technique, Relaxation technique, aspects of numerical dissipation and dispersion. Alternating-Direction-Implicit (ADI) Technique, pressure correction technique: application to incompressible viscous flow, need for staggered grid. Philosophy of pressure correction method, pressure correction formula. Numerical procedures: SIMPLE, SIMPLER, SIMPLEC and PISO algorithms, boundary conditions for the pressure correction method.
MODULE V	**FINITE VOLUME METHODS**
	Basis of finite volume method, conditions on the finite volume selections, cell-centered and cell vertex approaches. Definition of finite volume discretization, general formulation of a numerical scheme, two dimensional finite volume methods with example.

TEXTBOOKS

1. J. D. Anderson, Jr., "Computational Fluid Dynamics - The Basics with Applications", Mc Graw Hill Inc, 2012.
2. D A Anderson, J C Tannehill, R H Pletcher, "Computational Fluid Mechanics and Heat Transfer", 1st edition, 1997.

REFERENCE BOOKS:

1. Hirsch, C., "Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics", Vol. I, Butter worth-Heinemann, 2nd edition, 2007.
2. Hoffmann, K. A. and Chiang, S. T., "Computational Fluid Dynamics for Engineers", Engineering Education Systems, 4th edition, 2000.
3. Patankar, S.V., "Numerical Heat Transfer and Fluid Flow", Hemisphere Pub. Corporation, 1st edition, 1980.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112/105/112105045/
2. https://nptel.ac.in/courses/112/106/112106294/
3. https://ocw.mit.edu/courses/mechanical-engineering/2-29-numerical-fluid-mechanics-spring-2015/lecture-notes-and-references/

COURSE WEB PAGE:

1. https://www.iare.ac.in/sites/default/files/R18/Computational_Aerodynamics.pdf
2. https://lms.iare.ac.in/index?route=course/details&course_id=455

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	-
CONTENT DELIVERY (THEORY)			
1	Computational Fluid Dynamics Introduction CFD is a Research tool, as a design tool	CO 1, CO 2	T2: 1.1-1.5, T1: 4.1
2	Applications of CFD in various branches of engineering.	CO 1	T2: 2.1-2.2, R1: 3.1
3	Models of fluid flow, Finite Control Volume Infinitesimal Fluid Element	CO 1	T2: 2.3-2.4
4	Substantial derivative, Physical meaning of Divergence of velocity	CO 1	T2: 2.5-2.6,
5	Continuty equation derivation and its physical significance	CO 1	T2: 3.3
6	Momentum equation derivation and its physical significance	CO 2	T2: 3.4
7	Energy equation derivation and its physical significance	CO 2	T2: 3.3
8	Physical Boundary Conditions, Significance of conservation form and their implication on CFD applications	CO 2	T2: 4.2
9	Significance of non-conservation form and their implication on CFD applications	CO 3	T2: 5.1
10	Strong and weak conservation forms	CO 3	T2: 5.2
11	Shock capturing and shock fitting approaches.	CO 1	T2: 4.5
12	Classification of quasi-linear partial differential equations by Cramer's rule method	CO 1	T1: 4.1
13	Classification of quasi-linear partial differential equations by Eigen value method	CO 3	T1: 4.2
14	General behaviour of different classes of partial differential equations.	CO 4	T1: 4.3
15	Similarity parameters: geometric, kinematic and dynamic similarity	CO 5	T2: 5.2
16	Partial different equations importance in understanding physical and CFD aspects of aerodynamic problems.	CO 5	T1 : 4.3
17	Methods of describing fluid motion:Lagragian and Eulerian approach	CO 5	T2: 5.2
18	Types of fluid flows and their mathematical formulation	CO 6	T1: 7.2
19	Different Mach numbers involving hyperbolic, parabolic and elliptic equations	CO 6	T1: 7.5
20	Dependence and range of influence for hyperbolic equations, Well-posed problems	CO 5	T1: 7.5

21	Introduction to Finite Difference approximation for first order derivatives.	CO 5	R2:7.5
22	Finite difference approximation for second order derivatives.	CO 6	R2:7.5
23	Finite difference approximation for mixed derivatives.	CO 5	R2:7.5
24	Explicit approaches, Pros and cons of higher order difference schemes	CO 5	R2:7.5
25	Implicit approaches, Pros and cons of higher order difference schemes	CO 5	T1 : 4.4
26	Difference equations- explicit and implicit approaches, Pros and cons of higher order difference schemes	CO 4	T2 : 3.3.1-3.3.4
27	Truncation and round-off errors, consistency, stability, accuracy, convergence.	CO 4	T1 : 4.5
28	Von Neumann stability analysis Physical significance of CFL stability condition.	CO 4	R1 : 6.1
29	Need for grid generation Structured grids	CO 4	R1 : 6.1.1, 6.1.3
30	Cartesian grids stretched (compressed) grids body fitted structured grids, H-mesh, C-mesh, O-mesh, I-mesh.	CO 4	R1 : 6.1.3, 6.1.4
31	Multi-block grids, C-H mesh, H-O-H mesh, overset grids	CO 4	R1 : 6.2/ R4 : 11.6
32	Adaptive grids, Unstructured grids Triangular/ tetrahedral cells, hybrid grids Quadrilateral/ hexahedra cells	CO 4	T1 : 6.5, 6.6, 6.7
33	Lax-Wendroff technique, Mac Cormack's technique Crank Nicholson technique.	CO 4	T1 : 6.8
34	Relaxation technique, aspects of numerical dissipation and dispersion.	CO 5	T1 : 6.8.2, 6.8.3 / R3 :6.6
35	Alternating Direction Implicit Technique, Pressure correction technique- application to incompressible viscous flow.	CO 5	T1 : 2.3, 2.4
36	Need for staggered grid. Philosophy of pressure correction method, Pressure correction formula	CO 5	R2:7.5
37	Numerical procedures, SIMPLE and SIMPLER algorithms, SIMPLEC and PISO algorithms	CO 4	R1 : 6.1
38	Boundary conditions for the pressure correction method, Basis of finite volume method conditions on the finite volume selections.	CO 5	T1 : 6.5, 6.6, 6.7
39	Cell-centered and cell-vertex approaches, Definition of finite volume discretization General formulation of a numerical scheme.	CO 6	R1 : 6.1.1, 6.1.3
40	3-dimensional finite volume method with convection and diffusion problem.	CO 6	T1 : 6.8.2, 6.8.3 / R3 :6.6

PROBLEM SOLVING/ CASE STUDIES			
1	Explain how the continuity equation derived from these flow models can be converted from conservative to non-conservative form.	CO 1	T2:5.6 R1:1.12.3
2	Explain and Differentiate shock fitting and shock capturing methods with the suitable diagram.	CO 1	T2:5.6 R1:1.12.3
3	Illustrate the non-conservative form of governing equations. Derive continuity equation in non-conservation form using infinitesimal small fluid element moving in space.	CO 1	T2:5.6 R1:1.12.3
4	Explain the mathematical and physical nature of flows governed by parabolic Equations with an illustration of a steady boundary layer flow.	CO 1	T2:5.10 R1:1.15
5	Explore the boundary layer flow for the parabolic equation by considering the nose region with the neat sketch.	CO 2	T2:5.18 R2:1.13.2
6	Explicit the general behavior of the different classes of partial differential equation – impact on physical and computational fluid dynamics with suitable example for each.	CO 2	T2:5.20 R1:1.17.1
7	Elucidate the domain and boundaries for the solution of hyperbolic equations for the three dimensional steady flow.	CO 3	T2:6.3 R1:2.6.1
8	Discuss the domain and boundaries for the solution of hyperbolic equations for the one and two dimensional unsteady flow with the suitable diagram.	CO 3	T2:6.3 R1:2.6.1
9	Illustrate the physical behavior of flows governed by hyperbolic equations with an example of steady, inviscid supersonic flow over a two dimensional circular arc airfoil.	CO 5	T2:6.5 R1:2.6.2
10	Illustrate the physical behavior of flows governed by parabolic equations with an example of steady boundary layer flows. Explain PNS model for high speed flows and explain its merits.	CO 5	T2:7.7 R1:2.10
11	Explain the Parabolized Navier-Stokes equations and well-posed problems.	CO 4	T2:7.7 R1:2.10
12	Write short notes on the following properties of numerical solutions of fluid flows: i) Stability ii) Consistency iii) Accuracy iv) Convergence.	CO 5	T2:7.11 R1:2.32
13	Illustrate the time marching solution for constructing the explicit finite difference module by considering one-dimensional heat conduction equation which is parabolic partial differential solution.	CO 4	T2:15.13 R1:8.7.2
14	Explain the difference equation by considering unsteady, one-dimensional heat conduction equation with constant thermal diffusivity with the neat sketch.	CO 6	T2:5.20 R1:1.17.1
15	Illustrate a stable case by comparing the numerical domain include the entire analytical domain and does not include the entire analytical domain with the neat sketch.	CO 6	T2:7.3 R1:2.8
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	What is Parabolized Navier-Stokes equation?	CO 1	T2:5.6 R1:1.12.3

2	What is Courant–Friedrichs–Lewy (CFL) condition?	CO 2	T2:5.18 R2:1.13.2
3	What is flux corrected transport method?	CO 4,5	T2:6.5 R1:2.6.2
4	What is Time-dependent density functional theory?	CO 5	T2:7.11 R2:2.10.2
5	What is convection–diffusion equation?	CO 5	T2:6.3 R3:2.6.1
	DISCUSSION OF QUESTION BANK		
1	Continuity, Momentum and Energy equations with significance of conservation and non-conservation forms and their implication on CFD applications	CO 1,2,3	T2:5.10 R1:1.15
2	CFD aspects of aerodynamic problems at different Mach numbers involving hyperbolic, parabolic and elliptic equations	CO 2,3	T2:6.1 R1:2.3
3	Von Neumann stability analysis and its physical significance of CFL stability condition	CO 4,5	T2:7.3 R1:2.8
4	Numerical procedures: SIMPLE, SIMPLER, SIMPLEC and PISO algorithms	CO 5,6	T2:7.11 R1:2.32
5	General formulation of a numerical scheme and a two dimensional finite volume methods with example	CO 4,6	T2:6.3 R3:2.6.1

Signature of Course Coordinator **HOD,AE**
Mr. A Rathan Babu Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

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

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

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

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

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

Signature of Course Coordinator **HOD,AE**

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

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**Computational Aerodynamics Laboratory**				
Course Code	AAEB22				
Program	B.Tech				
Semester	VI	AE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Mr. A. Rathan Babu, Assistant Professor				

I COURSE OVERVIEW:

Computational Aerodynamics laboratory sessions focus on the creation of geometry, meshing (Discretization) and the physics applied to aerodynamics in order to visualize fluid flow and temperature distribution, and estimating the flow parameters around the aerodynamic body. Computational Aerodynamics laboratory also covers the usage of finite difference methods and necessary coding techniques. In this lab course, the students are trained on conducting simulations using the numerical methods analysis tool of CAD systems. The simulations include fluid, structural, thermal systems in the emerging technologies of interdisciplinary applications such as mechanical, aerospace, refrigeration systems.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB03	IV	Aerodynamics

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Computational Aerodynamics Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	The concepts of grid generation techniques for simple and complex domains to model fluid flow problems.
II	The aspects of numerical discretization techniques such as finite volume and finite difference methods.

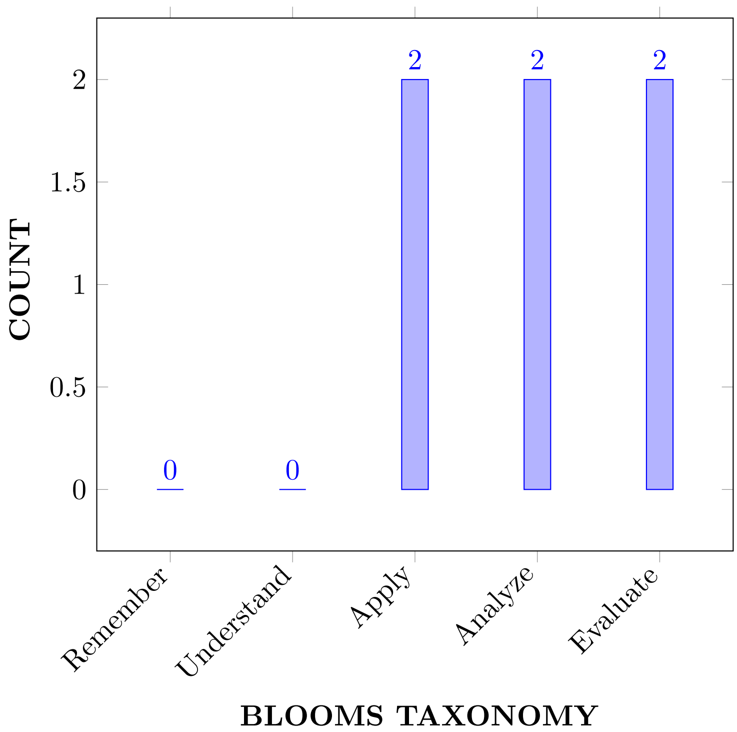
III	The mathematical modeling of different classes of partial differential equations to show their impact on computational fluid dynamics.
IV	The characteristics of different turbulence models and numerical schemes for estimating the criteria of stability, convergence, and error of fluid flow problem.

VII COURSE OUTCOMES:

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

CO 1	**Choose** the finite difference method at grid points of the domain for understanding discretization technique in solving fluid flow problem.	Apply
CO 2	**Classify** the nature of fluid flow problems for solving the governing equations using computational methods.	Analyze
CO 3	**Make use of** the computational methods and algorithms for obtaining solutions of fluid flow problems using ANSYS.	Apply
CO 4	**Simplify** the parameters of thermo-fluid systems using simulation methods for validating numerical and experimental results.	Analyze
CO 5	**Estimate** the aerodynamic forces on the slender and bluff bodies for calculating the lift and drag coefficients.	Evaluate
CO 6	**Assess** the numerical solution of fluid flow problems using discretization methods and convergence criteria for better results and minimize the errors.	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Lab Exercises/CIE/SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	Lab Exercises/CIE/SEE
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Lab Exercises/CIE/SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	Lab Exercises/CIE/SEE
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	3	Lab Exercises/CIE/SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Lab Exercises/CIE/SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	3	Lab Exercises/CIE/SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the basic conservation laws of science for various phenomena of fluid systems and use mathematical principles**mathematical principles** for deriving (complex) fluid flow engineering equations by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals**of fluid mechanics	3
	PO 2	Develop the computational programs for governing equations of fluid flow problems from the **temperature distribution** and velocity propagation are calculated from numerical methods using **mathematical principles** and **engineering fluid thermal sciences.**	2
	PO 3	**Identify**the available partial differential equations (analytical methods) for engineering fluid flow problems and apply a **computer software (CFD)** to **provide solutions** by **analyzing** analyzing the processes **in various applications**.	2
	PO 4	Outline the finite element methods adopted in **computational techniques**for **simulation**of fluid thermal systems for **innovative career**path in industry for **modern tool** usage.	2
	PO 5	Understand the (given **problem statement**) calibration procedure for (provided **information and data**) in reaching substantiated conclusions by the interpretation of results	3
	PO 9	Understand the (given **problem statement**) effects of viscosity, and capillary rise for the bodies immersed in fluids. (from the provided **information**) in solving analysis problems.	3
	PO 10	Recognize (knowledge) the importance and application (apply) of dimensions, units and dimensional homogeneity in solving (complex) engineering problems with specific emphasis to fluid mechanics by applying the **principles of Mathematics, Science and Engineering**	2
	PO 12	Understand the given **problem statement and formulate** the dimensional analysis and similarity parameters for predicting physical parameters that govern fluid systems in designing prototypes devices	3
	PSO 3	Apply (**knowledge**) properties, various types and patterns of fluid flow configurations (apply) for solving design problems by applying the **principles of Mathematics, Science and Engineering**	2

CO 2	PO 1	Develop the computational programs for governing equations of fluid flow problems from the **mathematical principles** and **engineering fluid thermal sciences.**	3
	PO 2	Identify the principles associated with heat transfer to **formulate** and calculate the flow field variables **using principles of mathematics, Design and engineering sciences.**	2
	PO 3	**Develop the Product, identify the proper solution** method for thermal equipment's used **in various applications** in the design and **evaluation of outcomes.**	2
	PO 4	**Identify the differential equations** (analytical methods) for engineering fluid flow problems and apply computer software (CFD) to provide solutions by analyzing the processes.	2
	PO 5	**Choose the necessary discretization methods to analyse** the stability of fluid system in the aspect of design the problems experimentally and numerically to recognize the significance of them in solving various engineering problems and creating solutions for thermal systems.	3
	PO 9	Understand fluid flow processes and the corresponding the context of **engineering knowledge related to different methods** of CFD and analyse the basic parameters influencing the flow by incorporating commercial CFD codes.	3
	PO 10	Understand the customer requirement, identify the proper finite differenece method for **complex thermal systems used in various applications**.	2
	PO 12	Apply appropriate finite difference technique to solve the complex thermal problems.	3
	PSO 3	Develop practical experience in building the real time products, using **industry standard and collaboration technique** in the field of Heat Exchangers.	2
CO 3	PO 1	Understand the given **problem statement and formulate** (complex) engineering problems by modeling ,meshing and applying corresponding boundary **information and data** in reaching substantiated conclusions by the**interpretation of results.**	3
	PO 2	**Identify**the available partial differential equations (analytical methods) for engineering fluid flow problems and apply a **computer software (CFD)** to **provide solutions** by **analyzing** analyzing the processes **in various applications**.	2
	PO 3	**Understanding** the basic processes to **conduct investigations of complex problems**in the **design, analysis to provide numerical solution** in order to minimize the T.E error.	2

	PO 4	Identify (Knowledge) the characteristics of various fluid flow processes, understand the corresponding the context of **engineering knowledge related to different methods** of CFD and analyse the basic parameters influencing the flow by incorporating commercial CFD codes.	2
	PO 5	Apply the available partial differential equations (analytical methods) for engineering fluid flow problems and apply computer software (CFD) to provide solutions by analyzing the processes.	3
	PO 9	Choose the necessary discretization methods to analyse the stability of fluid system in the aspect of design the problems experimentally and numerically to recognize the significance of them in solving various engineering problems and creating solutions for thermal systems.	3
	PO 10	**Apply the skills** of CFD methods in advanced industry trends based on engineering concepts.	1
	PO 12	Apply appropriate finite difference technique to solve the complex fluid problems.	3
	PSO 3	Develop practical experience in building the real time products, using **industry standard and collaboration technique** in the field of Heat Exchangers.	2
CO 4	PO 1	Select appropriate finite difference methods for numerical formulations from the fundamentals of mathematics and engineering **fluid thermal sciences.**	3
	PO 2	**Identify** and Understand the given fluid flow problem and **formulate**the appropriate CFD technique by using **first principles of mathematics** (Partial differential equations) to get analytical **solutions** in order to**validate results.**	2
	PO 3	Identify the various properties of condensation to heat engines techniques using**Design, analytical and mathematical process for problem analysis**	2
	PO 4	**Identify and Understand** the given fluid flow problem and formulate the appropriate CFD technique by using first principles of mathematics (Partial differential equations) to get analytical solutions in order to validate results.	3
	PO 5	**Formulate the problem statement and identify** the suitable finite difference method to obtain substantiated conclusions by the interpretation of results.	3
	PO 9	**Understand the customer requirement, identify** the proper finite volume method for complex thermal systems used in various applications.	3
	PO 10	Identify the available partial differential equations (analytical methods) for **engineering fluid flow problems and apply** computer software (CFD) to provide solutions by analyzing the processes.	2
	PO 12	**Build up (Apply) the skills** in the actual implementation of grid methods in industry trends based on advanced engineering concepts.	3

	PSO 3	Develop practical experience in building the real time products, using **industry standard and collaboration technique** in the field of Heat Exchangers.	3
CO 5	PO 1	**Analyse** the different discretization methods for solving thermal problems by using **engineering fundamentals in fluid sciences using mathematical equations** (partial differential equations) to minimise the errors.	3
	PO 2	Develop expression for aerodynamic coefficient and Identify the appropriate type of heat exchangers for **complex, problem analysis using engineering sciences.**	2
	PO 3	**Understand the customer (Product) requirement, identify the proper solution** method for thermal equipment's used **in various applications** in the design and **evaluation of outcomes.**	3
	PO 4	**Identify the available partial differential equations** (analytical methods) for engineering fluid flow problems and apply computer software (CFD) to provide solutions by analyzing the processes.	2
	PO 5	**Select the necessary discretization methods to analyse** the stability of fluid system in the aspect of design the problems experimentally and numerically to recognize the significance of them in solving various engineering problems and creating solutions for thermal systems.	3
	PO 9	Understand the characteristics of various fluid flow processes, understand the corresponding the context of **engineering knowledge related to different methods** of CFD and analyse the basic parameters influencing the flow by incorporating commercial CFD codes.	3
	PO 10	Understand the customer requirement, identify the proper finite volume method for **complex thermal systems used in various applications**.	3
	PO 12	Apply appropriate finite volume technique to solve the complex fluid thermal problems.	3
	PSO 3	Outline the finite volume methods adopted in **computational techniques for simulation** of fluid thermal systems for **innovative career** path in industry for**modern tool** usage.	3
CO 6	PO 1	Analyze the different discretization methods for solving thermal problems by using **engineering fundamentals in fluid sciences**using **mathematical equations** (partial differential equations) to minimize the errors.	3
	PO 2	**Identify, define** the necessary discretization methods to analyze the stability of fluid system in the aspect of **design** the problems experimentally and numerically to recognize the significance of them in **solving various engineering problems and creating solutions for thermal systems.**	2

	PO 3	**Knowledge and understanding** the basic processes to **conduct investigations of complex problems**in the **design, analysis to provide numerical solution** in order to minimize the error.	2
	PO 4	Recognize (Knowledge) the characteristics of various fluid flow processes, understand the corresponding the context of **engineering knowledge related to different methods** of CFD and analyse the basic parameters influencing the flow by incorporating commercial CFD codes.	3
	PO 5	Identify the available partial differential equations (analytical methods) for engineering fluid flow problems and apply computer software (CFD) to provide solutions by analyzing the processes.	3
	PO 9	Select the necessary discretization methods to analyse the stability of fluid system in the aspect of design the problems experimentally and numerically to recognize the significance of them in solving various engineering problems and creating solutions for thermal systems.	3
	PO 10	**Apply the skills in the actual implementation** of CFD methods in advanced industry trends based on engineering concepts.	2
	PO 12	Apply appropriate finite volume technique to solve the complex thermal problems.	3
	PSO 3	Outline the finite volume methods adopted in **computational techniques for simulation** of fluid thermal systems for **innovative career** path in industry for**modern tool** usage.	3

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

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

XIII ASSESSMENT METHODOLOGY DIRECT:

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

XIV ASSESSMENT METHODOLOGY INDIRECT:

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

XV SYLLABUS:

WEEK I	**INTRODUCTION**
	Introduction to computational aerodynamics, the major theories, approaches and methodologies used in computational aerodynamics. Applications of computational aerodynamics for classical aerodynamic‘s problems.
WEEK II	**INTRODUCTION TO ICEM CFD**
	Introduction to ICEM CFD, geometry creation, suitable meshing types and boundary conditions.
WEEK III	**INTRODUCTION TO FLUENT**
	Introduction to fluent, boundary conditions, solver conditions and post processing results.
WEEK IV	**FLOW OVER A FLAT PLATE**
	Flow over a flat plate at low Reynolds numbers, observe the boundary layer phenomena, no slip condition and velocity profile inside the boundary layer.
WEEK V	**FLOW THROUGH PIPE**
	Flow through pipe at different Reynolds numbers; observe the velocity changes for laminar and turbulent flows.
WEEK VI	**FLOW OVER A CIRCULAR CYLINDER**
	Flow over a circular cylinder at different Reynolds numbers, observe the properties at separation region and wake region.
WEEK VII	**FLOW OVER A CAMBERED AEROFOIL**
	Flow over a cambered aerofoil at different Reynolds number, observe flow properties and compare the computation results with experimental results (consider the model from aerodynamics laboratory).
WEEK VIII	**FLOW OVER A SYMMETRIC AEROFOIL**
	Flow over a symmetric aerofoil at different Reynolds number, observe flow properties and compare the computation results with experimental results (consider the model from aerodynamics laboratory).
WEEK IX	**FLOW OVER WEDGE**
	Flow over wedge body at supersonic Mach number; observe the shock wave phenomena and change of properties across the shock wave.
WEEK X	**FLOW OVER A CONE**
	Flow over a cone at supersonic Mach number; observe the shock waves and 3D relieving effect.
WEEK XI	**CODE DEVELOPMENT**
	Solution for the following equations using finite difference method I. One dimensional wave equation using explicit method of lax. II. One dimensional heat conduction equation using explicit method.

WEEK XII	**CODE DEVELOPMENT**
	Generation of the following grids I. Algebraic grids. II. Elliptic grids.

Reference Books:

1. Anderson, J.D., Jr., Computational Fluid Dynamics The Basics with Applications, McGraw-Hill Inc, 1st Edition 1998.
2. Hoffmann, K. A. and Chiang, S. T., —Computational Fluid Dynamics for Engineers, 4th Edition, Engineering Education Systems (2000).
3. Hirsch, C., —Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics, Vol. I, 2nd Edition., Butterworth-Heinemann (2007).
4. JAF. Thompson, Bharat K. Soni, Nigel P. Weatherill —Grid generation, 1st Edition 2000.

XVI COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Introduction.	CO 1	R1: 2.3
2	Introduction to ICEM CFD.	CO 3,CO 4,CO 6	R2: 2.6
3	Introduction to fluent.	CO 2, CO 3	R1: 2.6
4	Flow over a flat plate.	CO 3,CO 4,CO 6	R2: 2.7
5	Flow through pipe.	CO 3, CO 4,CO 7	R3: 2.22
6	Flow over a circular cylinder.	CO 3, CO 4	R2: 2.25
7	Flow over a cambered aerofoil.	CO 4,CO 7	R3: 2.55
8	Flow over a symmetric aerofoil.	CO 3, CO 4,CO 7	R2: 2.3
9	Flow over wedge.	CO 4,CO 5	R1: 2.6
10	Flow over a cone.	CO 3,CO 4, CO 6	R2: 2.8
11	Code development.	CO 3,CO 6,CO 7	R1:2.18
12	Code development.	CO 3,CO 6,CO 7	R4:2.22

XVII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Aerodynamic analysis on wing.
2	Flow Through Diffuser.
3	Subsonic flow in a convergent divergent nozzle.
4	Analysis of heat pipe using volume of fluid method.
5	Flow through supersonic intake.

Signature of Course Coordinator **HOD,AE**
Mr.A. Rathan Babu, Assistant Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**EXPERIMENTAL AERODYNAMICS**				
Course Code	AAEB35				
Program	B.Tech				
Semester	VI	AE			
Course Type	Elective				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr Aravind Rajan Ayagara, Associate Professor				

I COURSE OVERVIEW:

The experimental aerodynamics is the first course for graduate and undergraduate students in Aerospace Engineering. The testing methodology employed in low and high-speed aerodynamics is a new techniques through which the students will learn various types of wind tunnels, tools and techniques. The experimental aerodynamics will be helpful to industrial aerodynamics study in various engineering branches like, environmental engineering, civil engineering, Automobile engineering etc., so that students get exposure to the various aspects of the subject related issues to measuring techniques, wind tunnel design, method and practical applications used. This subject will help the students to develop the tool by using multidisciplinary techniques. A number of problems/examples will be cited to enhance the understanding of the subject matter and besides, many unsolved problems will be provided with answers to further test the student's learning.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AAEB10	IV	Aerodynamics
UG	AAEB15	V	High Speed Aerodynamics

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Experimental Aerodynamics	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 2), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (Table 3).

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

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

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

Alternative Assessment Tool (AAT)

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

5 Minutes Video	Assignment	Tech-talk	Seminar	Open Ended Experiment
20%	30%	30%	10 %	10 %

VI COURSE OBJECTIVES:

The students will try to learn:

I	The constructions of low speed tunnel, high speed tunnels, transonic, supersonic and hypersonic tunnels and geometric similarity, kinematic similarity and dynamic similarity experiment techniques used for analysis aerodynamic problems.
II	The description, design constraints and loss coefficients, and estimation and correction of blockages in wind tunnels for receiving precise values while conducting experiments
III	The principles and applications of Load measurement, Pressure, Velocity, Temperature and flow visualization techniques used in wind tunnel for validating the results experimentally.
IV	The necessity of wind tunnel experiments in the fields of automobile and aerospace for the analysis of aerodynamic problems

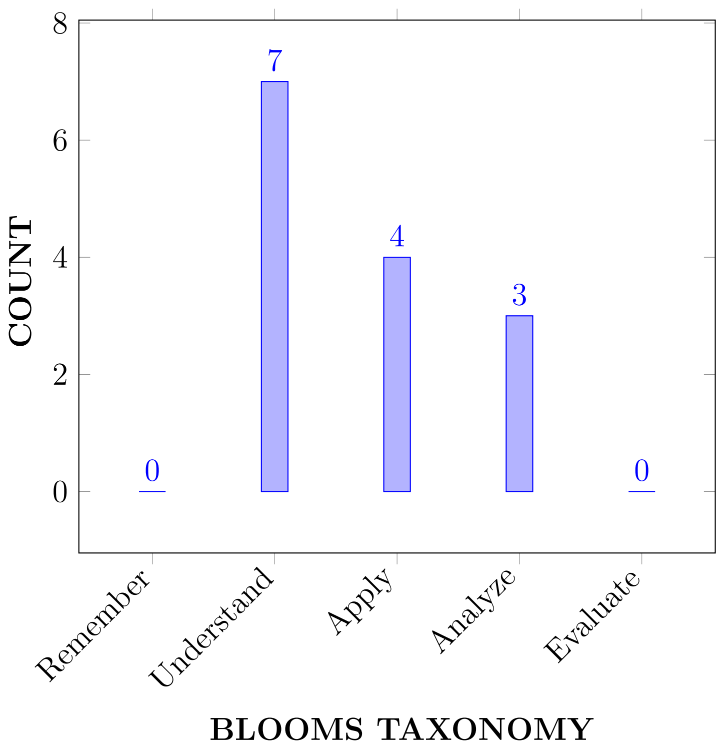
VII COURSE OUTCOMES:

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

CO 1	**Explain**the need of wind tunnel and its measuring techniques for analysis of model using geometric similarity, kinematic similarity and dynamic similarity.	Remember
CO 2	**Classify**the types of wind tunnels based on wind speeds for designing the prototypes and their applications aerospace industries	Understand
CO 3	**Identify**the principal components of low speed wind tunnel and their functions fordetermining loss coefficients and constraints.	Apply
CO 4	**Illustrate** the methods for the improvements of wind tunnel performance and corrective measures for obtaining accurate results with wind tunnel experiments.	Understand
CO 5	**Demonstrate** low speed wind tunnel balances, mechanical and Strain gauge types, null displacement methods and strain method and etcforload measurement using wind tunnel balance.	Understand

CO 6	**Explain**the model supports used in wind tunnel for load measurement.	Understand
CO 7	**Identify** the principles of probes and transducers used in pressure, velocity & temperature measurements techniques.	Apply
CO 8	**Demonstrate** methods used for equipment's settings, calibration, measurement data, and processing of gauges used in vof pressure, velocity and temperature measurements.	Understand
CO 9	**Identify**thenecessity of streamlines, streak lines, path lines, time lines, tufts, china clay, oil film, smoke and hydrogen bubble for flow visualization of wind in wind tunnel.	Understand
CO 10	**Demonstrate**the relative merits and demerits of flow visualization techniques followed with their applications for flow visualization in wind tunnel.	Apply
CO 11	**Identify** the applications of wind tunnels for the analysis of load, pressure, velocity and temperature measurements using flow visualization forthe analysis of aerodynamic problems in automobile and aerospace industries.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/SEE/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/SEE/AAT
PO 9	**Individual and Teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	1	CIE/SEE/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.	12	CIE/SEE/AAT

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	1	Seminars

3 = High; 2 = Medium; 1 = Low

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

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

CO 4	✓	✓	-	-	-	-	-	-	✓	✓	-		-	✓	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-
CO 6	✓	✓	-	-	-	-	-	-	-	-	-		-	✓	-
CO 7	✓	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-
CO 8	✓	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-
CO 9	✓	✓	-	-	-	-	-	-	✓	✓	-	-	-	✓	-
CO 10	✓	✓	-	-	-	-	-	-	✓	✓	-	-	-	✓	-
CO 11	✓	✓	-	-	-	-	-	-	✓	✓	-	-	-	✓	-
CO 12	✓	✓	-	-	-	-	-	-	✓	✓	-	-	-	✓	-

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** to classify various rocket propulsion systems and missiles	3
	PO 2	**Identify the problem statement** (mission requirement), select the appropriate missile required for destroying target by reviewing the literature (information and data collection) suitable to mission requirement	2
	PSO 2	**Apply (knowledge)** the need of wind tunnels and their measuring techniques (understanding), for analysis of model using geometric similarity, kinematic similarity and dynamic similarity (apply) solving aircraft design problems by applying the principles of mathematics, science and Engineering	2
CO 2	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** and derive the rocket thrust equation under different flight conditions	3
	PO 2	Analyze the performance parameters of rocket and various forces acting on a rocket using **first principles of Mathematics and engineering sciences.**	2
	PSO 2	**Apply (knowledge)** the need of wind tunnels and their measuring techniques (understanding), for analysis of model using geometric similarity, kinematic similarity and dynamic similarity (apply) solving aircraft design problems by applying the principles of mathematics, science and Engineering	2
CO 3	PO 1	Identify various chemical rocket propulsion systemsand its propellants **using principles of mathematics, science, and engineering fundamentals.**	3

	PO 2	Analyze the performance parameters of rocket and various forces acting on a rocket using **first principles of Mathematics and engineering sciences.**	2
	PSO 2	**Apply (knowledge)** the need of wind tunnels and their measuring techniques (understanding), for analysis of model using geometric similarity, kinematic similarity and dynamic similarity (apply) solving aircraft design problems by applying the principles of mathematics, science and Engineering	2
CO 4	PO 1	Apply the knowledge of different forces (**scientific Principles and mathematical principles**) for chemical rocket engine and describe different performance parameters.	3
	PO 2	Determine the grain parameters and rocket performance parameters **using first principles and Mathematics and Engineering sciences.**	4
	PO 9	Individual and Teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings of aircraft structural design.	5
	PO 10	Communication: Communicate effectively on complex Engineering activities with the Engineering community, write effective reports, design documentation, effective presentations and give and receive clear instructions.	5
CO 5	PO 1	Understand the advantages of solid propellant, monopropellant and Bi-propellant to determine the desirable properties of oxidizer, Inert gas and fuel **using the fundamentals of engineering and mathematical equations**	3
CO 6	P 1	Analyze different Engine cycles used for propulsion system of a chemical rocket engine **using fundamentals of science &and engineering fundamentals.**	3
)	PO 2	Categorize the concept of Pyrotechnics based on its physical state and its usage in **complex engineering problems.**	3
	PO 3	Investigate and define a problem and identify constraints of Pyrotechnics including **environmental and sustainability limitations, health and safety and risk assessment issues** when dealing with performance of gaseous mixtures and their application on real world problems	2
CO 7	PO 1	Understand (**knowledge**) different combustion instabilities w.r.t time for various chemical rocket engines during flight by **applying the knowledge of sciences and Engineering fundamentals principles**	3

	PSO 1	**Synthesize** and **analyze** different combustion systems for non-air breathing engines to provide thrust for the Rockets and missiles	2
CO 8	PO 1	Describe (**Knowledge**) different guidance phases and guidance systems for a cruise and ballistic missile **using principles of mathematics, natural science, and engineering fundamentals.**	3
	PSO 2	Extend the focus to **understand the innovative and dynamic challenges** involve the guidance system of rocket and missiles for specific role.	1
CO 9	PO 1	Evaluate the performance characteristics of single stage and multistage rocket using the basic **understanding of engineering science and mathematical equations**	3
	PO 2	**Identify the problem statement** (mission requirement), select the number of stages required for placing a payload into the orbit by reviewing the literature (**information and data collection**) suitable to mission requirement	2
CO 10	PO 1	**Apply the knowledge of engineering fundamentals** to test the prototype of rockets and various safety measures that should be taken while testing.	3
CO 11	PO 1	**Apply the knowledge of Sciences and Engineering fundamentals** for design and development of TVC mechanism and cooling systems for rocket propulsion system.	3
	PO 2	Identify the proper cooling system and TVC mechanism for a chemical rocket engine (**complex system**) **using first principle of natural sciences and Engineering sciences.**	4
	PO 9	Individual and Teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings of aircraft structural design.	3
	PO 10	**Apply the knowledge of Sciences and Engineering fundamentals** for design and development of TVC mechanism and cooling systems for rocket propulsion system.	3
	PSO 2	**Apply (knowledge)** the need of wind tunnels and their measuring techniques (understanding), for analysis of model using geometric similarity, kinematic similarity and dynamic similarity (apply) solving aircraft design problems by applying the principles of mathematics, science and Engineering	2

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

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

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

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

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	3	-	
CO 2	3	1	-	-	-	-	-	-	-	-	-				-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	3	-	
CO 4	3	1	-	-	-	-	-	-	2	3	-	-	3	-	
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	3	-	
CO 6	3	-	-	-	-	-	-	-	-	-	-	-	3	-	
CO 7	3	-	-	-	-	-	-	-	-	-	-	-	3	-	
CO 8	3	-	-	-	-	-	-	-	-	-	-	-	3	-	
CO 9	3	1	-	-	-	-	-	-	2	3	-	-	3	-	
CO 10	3	1	-	-	-	-	-	-	2	3	-	-	3	-	
CO 11	3	1	-	-	-	-	-	-	2	3	-	-	3	-	
TOTAL	33	8							8	12			3		
AVERAGE	3	1							2	3			3		

XV ASSESSMENT METHODOLOGY DIRECT:

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

XVI ASSESSMENT METHODOLOGY INDIRECT:

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

XVII SYLLABUS:

MODULE I	**FUNDAMENTALS OF EXPERIMENTS IN AERODYNAMICS**
	Forms of aerodynamic experiments, observations, measurement objectives. History: Wright Brothers wind tunnel, model testing, wind tunnel principles, scaling laws, scale parameters, geometric similarity, kinematic similarity& dynamic similarity. Wind tunnels: low speed tunnel, high speed tunnels, transonic, supersonic and hypersonic tunnels, shock tubes. Special tunnels: low turbulence tunnels, high Reynolds number tunnels, environmental tunnels, automobile tunnels, distinctive features, application.
MODULE II	**WIND TUNNEL EXPERIMENTATION CONSIDERATIONS**
	Low speed wind tunnels, principal components. Function, description, design requirements, constraints and loss coefficients. Wind tunnel performance flow quality, power losses, wind tunnel corrections, sources of inaccuracies: buoyancy, solid blockage, wake blockage, streamline curvature causes, estimation and correction.
MODULE III	**WIND TUNNEL BALANCE**
	Load measurement: low speed wind tunnel balances, mechanical & Strain gauge types, null displacement methods & strain method, sensitivity, weigh beams, steel yard type and current balance type, balance linkages, levers and pivots. Model support three point wire support, three point strut support, platform balance, yoke balance, strain gauge, 3-component strain gauge balance, description, application.
MODULE IV	**PRESSURE, VELOCITY & TEMPERATURE MEASUREMETNS**
	Pressure: static pressure, surface pressure orifice, static probes, pitot probe for total pressure, static pressure and flow angularity, pressure sensitive paints, steady and unsteady pressure measurement and various types of pressure probes and transducers, errors in pressure measurement. Temperature: measurement of temperature using thermo couples, resistance thermometers, temperature sensitive paints and liquid crystals. Velocity: measurement of airspeed, Mach number from pressure measurements, flow direction, boundary layer profile using pitot static probe, 5 hole probe yaw meter, total head rake, hot wire anemometry, laser doppler anemometry, particle image velocimetry, working principle description of equipment, settings, calibration, measurement, data processing, applications.

MODULE V	**FLOW VISUALIZATION TECHNIQUES**
	Flow visualization: necessity, streamlines, streak lines, path lines, time lines, tufts, china clay, oil film, smoke, hydrogen bubble. Optical methods: density and refractive index, schlieren system, convex lenses, concave mirrors, shadow graph, interferometry, working principle, description, setting up, operation, observation, recording, interpretation of imagery, relative merits and applications.

TEXTBOOKS

1. 1. Jewel B Barlow, William H Rae Jr. & Alan Pope, "Low Speed Wind Tunnel Testing", John Wiley& Sons Inc, Re-Print, 1999.
2. Alan Pope, Kennith L Goin, "High Speed Wind Tunnel Testing", John Wiley & Sons, 1965.

REFERENCE BOOKS:

1. 1. Gorlin S M &Slezinger II, Wind tunnels & Their Instrumentations, NASA publications, Translated version, 1966.
2. 2. Jorge C Lerner &UlfilasBoldes, Wind Tunnels and Experimental Fluid Dynamics research, InTech, 1st Edition, 2011.
3. 3. Liepmann H W and Roshko A, Elements of Gas Dynamics, John Wiley & Sons, 4th Edition, 2003.

XVIII COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
1	Introduction and need of experimental test	CO 1, CO 11	T2:26.3
2-3	Experimental Test requirements and history	CO 1, CO 8	R2:21.48
4-5	Types of Wind tunnels and their requirements	CO 1, CO 9	T2:26.6 R2:21.50
6-9	Wind tunnels for industrial and various applications apart from aerospace requirements	CO 2, CO 11	T2:26.7 R2:21.51
9-11	Introduction wind tunnel experimentation considerations	CO 2, CO 11	T2:26.8
12-13	Experimental requirements and design constraints	CO 3, CO 11	T2:26.10
14-15	Wind tunnel quality and performance	CO 4, CO 5, CO 11	T2:26.14 R2:21.55
16-18	Source of errors and correction methodology	CO 4,CO 5, CO 11	T2:26.15 R2:21.58

19-20	Introduction to wind tunnel balance	CO 4,CO 5, CO 11	T2:26.16 R2:21.61
21-22	Mounting techniques of models	CO6, CO 8, CO 11	T2:25.12 R2:21.24
23-25	Various techniques used in wind tunnels	CO 6, CO 10, CO 11	T2:25.16 R2:21.29
26-27	Useful applications	CO 6, CO 10, CO 11	T2:25.14 R2:21.31
28-29	Introduction to tools and techniques used in wind tunnels	CO 6, CO 8, CO 11	T2:25.14 R2:21.33
30-32	Flow measurements techniques for steady and unsteady flow	CO 6, CO 10, CO 11	R2:21.33
33-35	Usage of electronic device and transducer	CO 6, CO 10, CO 9	T2:27.2 R2:21.64
36-37	Hot wire anemometry	CO 6, CO 10, CO 9	T2:27.2
38-41	Laser Doppler anemometry and working principle	CO 6, CO 10, CO 11	T2:27.2 R2:21.67
42-43	Data processing tools and techniques	CO 6, CO 10, CO 11	T2:27.2
44-45	Various flow visualization techniques	CO 7, CO 10, CO 11	T2:27.3 R2:21.71
46-48	Schlieren system and set up, Merits and demerits of various flow visualization techniques.	CO 7, CO 10, CO 11	T2:27.4 R2:21.68

Signature of Course Coordinator **HOD,AE**
Dr Aravind Rajan Ayagara, Associate Professor

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

COURSE DESCRIPTION

Department	**AERONAUTICAL**				
Course Title	**ROCKET AND MISSILES**				
Course Code	AAEB40				
Program	B.Tech				
Semester	VI				
Course Type	ELECTIVE				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3		
Course Coordinator	Mr V. Phaninder Reddy, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB08	IV	Aerospace Propulsion
B.Tech	AAEB10	IV	Aerodynamics

II COURSE OVERVIEW:

This course deals with fundamental aspects of rockets and the current trends in rocket propulsion. This course includes the combustion process, propellants and various components of chemical rocket propulsion systems and their applications. It compares and contrasts various thrust vector control mechanisms of nozzle and cooling systems of combustion chamber. It discusses on various materials and its properties that are used for manufacturing of rocket and missiles. This course also covers the basic concepts of guidance of missile and various types of tactical guidance systems and techniques.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Rocket and Missiles	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

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

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

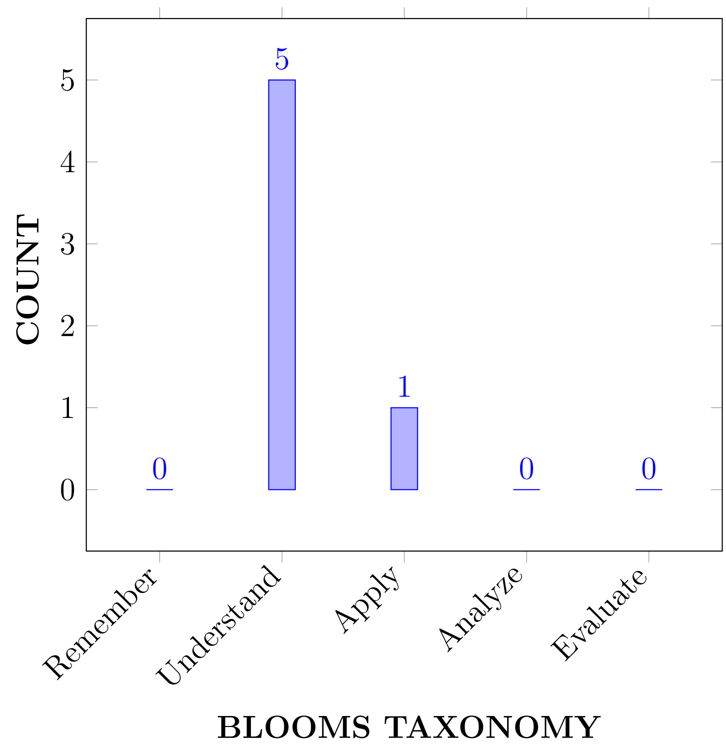
I	The fundamental concepts of various rocket propulsion systems, combustion process and forces/moments acting on the rocket under static and dynamic conditions.
II	The operating principle of guided missile, and the guidance, control and instrumentation needed to acquire the target.
III	Properties of different materials that are used in manufacturing of various rocket and missile components .

VII COURSE OUTCOMES:

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

CO 1	**Utilize** the working principle of different types of rocket propulsion systems for distinguishing them based on the mission requirement.	Apply
CO 2	**Discuss** different design concepts implemented in solid rocket motor and liquid rocket engine for selecting the best propellant	Understand
CO 3	**Identify** performance parameters of chemical rocket and propellants for relating thrust and burn characteristics.	Apply
CO 4	**Summarize** various combustion process and commonly used propellants of a chemical rocket engine for identifying the optimal combinations based on specific application	Understand
CO 5	**Categorize** various missiles and their appropriate guidance system to provide sufficient capability (speed, range, and maneuverability) and accomplish the mission planned for the system	Understand
CO 6	**Understand** selection criteria and properties of materials to perform under adverse conditions for design of new components as per the requirements.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards	3	Quiz/AAT
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	1	Quiz/AAT

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Apply the knowledge of sciences and engineering fundamentals principles** to classify various rocket propulsion systems	2
	PO 2	**Identify the problem statement** (mission requirement), select the appropriate missile required for destroying target by reviewing the literature (information and data collection) suitable to mission requirement	2
CO 2	PO 1	**Apply the knowledge of sciences and engineering fundamentals** for design and development of igniters, injectors TVC mechanism and cooling systems for rocket propulsion system.	2
	PO 2	Identify the igniters,injectors, cooling system and TVC mechanism for a chemical rocket engine (**complex system**) **using first principle of natural sciences and Engineering sciences.**	2
CO 3	PO 1	Apply the knowledge of different forces (**scientific Principles and mathematical principles**) for chemical rocket engine and describe different performance parameters.	3
	PO 2	Determine the grain parameters and rocket performance parameters **using first principles and Mathematics and Engineering sciences.**	2
CO 4	PO 1	Understand (**knowledge**) different combustion processes and engine cycles w.r.t time for various chemical rocket engines during flight by **applying the knowledge of sciences and engineering fundamentals principles**	2
	PSO 1	**Synthesize** and **analyze** different combustion systems for non-air breathing engines to provide thrust for the rockets and missiles	2
CO 5	PO 1	Describe (**Knowledge**) different guidance phases and guidance systems for a cruise and ballistic missile **using principles of natural science, and engineering fundamentals.**	2
	PSO 2	Extend the focus to **understand the innovative and dynamic challenges** involve the guidance system of rocket and missiles for specific role.	1
CO 6	PO 1	**Apply the knowledge of sciences and engineering fundamentals** to select the materials for various rocket components .	2
	PO 2	Identify different metals, alloys and composite materials for different components of a chemical rocket engine (**complex system**) **using first principle of natural sciences and Engineering sciences.**	2

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	67	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	67	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	67	-	-	-	-	-	-	-	-	-	-	-	100	-	-
CO 5	67	-	-	-	-	-	-	-	-	-	-	-	-	50	-
CO 6	67	20	-	-	-	-	-	-	-	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**ROCKET DYNAMICS**
	Classification of launch vehicles and missiles, rocket systems, airframe components, forces and moments acting on a rocket, propulsion, aerodynamics, gravity, inertial and non-inertial frames, coordinate transformation, equations of motion for three-dimensional motion through atmosphere and vacuum, earth's atmosphere, numerical problems
MODULE II	**SOLID PROPULSION AND PYROTECHNICS**
	Solid propellant rockets, classification, components and their design considerations, propellant grain design, grain mechanical properties, ballistics and burn rate design issues, igniter design, types of nozzles, thrust vector control, pyrotechnic devices and systems, classification, mechanisms and application of pyrotechnic devices in rockets and missiles; design problems in rocket systems
MODULE III	**LIQUID PROPULSION AND CONTROL SYSTEMS**
	Liquid propellant rockets, classification and components, thrust chamber, feed systems, propellant tanks, turbo-pumps, types of valves and applications, design considerations. Different bipropellant systems like cryogenics and their characteristics, pogo and slosh engine gimbal systems and thrusters for control; Spacecraft propulsion and control systems design problems.
MODULE IV	**MULTI-STAGING OF ROCKET AND SEPERATION DYNAMICS**
	Navigation and guidance systems in rockets and missiles, aerodynamic control systems of missiles, multistaging of rockets, vehicle optimization techniques, stage separation system, dynamics, separation techniques, rocket flight dispersion, numerical problems
MODULE V	**DESIGN, MATERIALS AND TESTING OF ROCKETS**
	Design requirements and selection, performance evaluation and assessment, space environment on the selection of materials for rockets and spacecraft, material selection for specific requirements, advance materials, super alloys and composite materials, qualification of rocket and missile systems, types of testing and evaluation of design and function

TEXTBOOKS

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

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

REFERENCE BOOKS:

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

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

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

COURSE WEB PAGE:

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
0	Course OBE Discussion		
CONTENT DELIVERY (THEORY)			
2	Classification of launch vehicles	CO 1	T2: 1.1-1.5, T1: 4.1
3	Classification of missiles and missiles developed by DRDO	CO 5	T2: 1.1-1.5, T1: 4.1
4	Rocket systems, airframe components, forces and moments acting on a rocket	CO 1	T2: 2.1-2.2, R1: 3.1
5	Aerodynamics, gravity, inertial and non-inertial frames	CO 3	T2: 2.3-2.4
6	Equations of motion for three-dimensional motion through atmosphere, and vacuum	CO 3	T2: 3.3
7	Cruise Missile and Ballistic missile along with examples and differences	CO 5	T2: 3.3
8	Specific impulse, Characteristic velocity, mass fraction, Total impulse, Effective exhaust velocity, Thrust coefficient	CO 3	T2: 3.3
9	Basic relations of motion, Effect of propulsion system on vehicle performance	CO 3	T2: 3.3
10	Solid propellant rockets, classification and components	CO 2	T2: 3.4
11	Propellant grain configurations and grain mechanical properties.	CO 4	T2: 3.3
12	Propellant classification, Propellant characteristics and Ingredients	CO 4	T2: 3.3
12	Ballistics and burn rate design issues, igniter design	CO 3	T2: 4.2

S.No	Topics to be covered	CO's	Reference
13	Types of nozzles, thrust vector control of SRM	CO 2	T2: 5.1
14	Pyrotechnic devices and systems, classification; Mechanisms and application of pyrotechnic devices in rockets and missiles	CO 4	T2: 5.2
15	Combustion instability of Solid rocket motor	CO 4	T2: 5.2
16	Pressure decay in the chamber after propellant burns out, Factors influencing the burn rate.	CO 4	T2: 4.5
17	Liquid propellant rockets, classification and components	CO 2	T2: 4.5
18	Pressure feed system, Propellant tanks and tank pressurization	CO 2	T2: 4.5
19	Turbopump feed system and Engine cycles, Valves and pipelines	CO 4	T2: 4.5
20	Different types of injectors in liquid rocket engine, TVC mechanisms in LRE	CO 2	T2: 4.5
21	Hydrazine as monopropellant, Bi propellant, gelled propellant and storable propellants, Liquid oxidizers and fuels	CO 4	T2: 4.5
21	Combustion instability in lquid rocket engines. Latest developments in LRE.	CO 4	T2: 4.5
22	Need for guidance system in missile and guidance phases of missile	CO 5	T1: 4.1
23	Classification of various guidance systems: Beamer rider guidance, Command guidance and Inertial guidance system, Homing guidance	CO 5	T1: 4.2
24	Missile control: Aerodynamic control, Thrust vector control, Elements of control system	CO 2	T1: 4.3
25	Design considerations of body of missile: Nose, Mid section and boat tail section	CO 2,5	T2: 5.2
26	Multistage of rockets ,Vehicle optimization techniques	CO 1	T2: 5.2
27	Stage separation system dynamics and techniques, Rocket flight dispersion numerical problems.	CO 1	T1: 7.2
28	Selection of materials for spacecraft for specific requirements, advance materials,	CO 6	T1: 7.5
29	Super alloys and composite materials	CO 6	T1: 7.5
30	Types of testing and evaluation of design and function	CO 6	R2:7.5
31	Heat Protection System of Spacecrafts and Missiles, Aerodynamic Heating and Solar Heating	CO 6	R2:7.5
PROBLEM SOLVING/ CASE STUDIES			
1	Thrust of the engine in a vacuum, Determine the change in velocity if the spacecraft burns, mass fraction	CO 1	T2: 1.1-1.5, T1: 4.1
2	Calculate the duration of the burn, exhaust gas velocity relative to the rocket, Calculate the specific impulse,area of the nozzle exit	CO 3	T2: 3.4

S.No	Topics to be covered	CO's	Reference
3	Calculate the ideal density of a solid rocket propellant, grain geometry, propellant mass, mass flow rate	CO 3	R4: 2.8
4	Determine impulse provided by each stage of rocket and total propellant carried in it	CO 3	R4: T6.3.2
5	Heat generated from combustion of liquid hydrogen, mixture ratio, find whether the composition is fuel rich or oxyrich	CO 3	R4: T6.3.2
6	Maximum chamber pressure, mass of propellant silver initial equilibrum chamber pressure	CO 4	R4: T6.3.2
7	Determine the heat to be transferred in the regenerative cooling passages	CO 4	R4:5.2
8	Specific impulse of gas generator fed cryogenic rocket, mixture ratio at injection	CO 4	T2: 5.2
9	Heat release per kg of Hydrazine, Characteristic velocity, mass flow rate of Hydrazine	CO 4	T2: 13.1-13.2.5
11	Stage mass ratios, Ideal velocities, propulsive efficiency, structural mass fraction of each stage, Thrust at each stages	CO 3	T4: 11.2-11.4
12	Propellant performance neglecting dissocaiation of combustion products, molecular mass of combustion products	CO 4	T2: 13.2.6
13	Calculate performance of gas generator, expander and stageed combustion engine cycle	CO 4	T4:14.3-14.4
14	Variation of pressure and burn time of hollow cylindrical grain	CO 3, 4	T4:14.3-14.4
15	Pressure decay in the combustion chamber after propellamt burns out.	CO 3	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Specific Impulse, characteristic velocity, Ion rocket propulsion. Ideal rocket equation, Working principle of rocket, cruise and ballistic missile	CO 1	T2: 1.1-1.5
2	Grain, Grain silver. progressive, neutral and regressive burn. Ammonium perchlorate, Double base and composite propellant. Pyrogen and Pyrotechnic igniter	CO 2,4	T4:7.3
3	Gas generator cycle, expander cycle and staged combustion cycle. Film cooling, Injector, Thrust vector control, Ullage, UDMH, Catalyst. Hypergolic, Cryogenic and Bi propellant propellant	CO 2,4	R4:5.1, T2: 6.3-6.4
4	Homing guidance, Beamer rider guidance, Multistage rocket, mass fraction and ideal velocity of multistage rocket. guidance phases, Aerodynamic controls of missile, sloshing	CO 5	T1:7.5
5	Nickel and titanium based alloys, Ablate materials, silica phenolic composites, refractory materials, ceramics, Metal alloys with face centered structure	CO 6	T1: 12.1

S.No	Topics to be covered	CO's	Reference
DISCUSSION OF QUESTION BANK			
1	Equations of motion, Calculation of rocket performance parameters, Rocket propulsion systems	CO 1,2,3	R4:2.1
2	Classification of igniters, Grain design parameters, Classification of SRM, Various propellants of solid rocket	CO 2,4	T4:7.3
3	TVC mechanism, Engine cycles, propellants of liquid rocket engine, Combustion instabilities in LRE, applications and advantages of liquid rocket engine	CO 2,4	R4:5.1
4	Guidance phase, Command guidance beamer rider guidance and Homing guidance. Multistage rockets.	CO 1,5	T1:7.5
5	Material used in various components of rocket along with its applications and advantages	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,AE**

Mr. V Phaninder Reddy

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

COURSE DESCRIPTION

Department	Aeronautical Engineering				
Course Title	Mechanism and Machine Design				
Course Code	AAEB43				
Program	B.Tech				
Semester	VI				
Course Type	ELECTIVE				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	4	-	-
Course Coordinator	Mr V Raghavender, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME002	III	Engineering Mechanics

II COURSE OVERVIEW:

Mechanism and Machine Design is the branch of engineering science, which deals with the study of relative motion between the various parts of machine and forces which act on them which leads to design of machines and parts of a machine. This course also discuss the effects of gyroscopic couple and power transmitting elements such as belt drives, cam and followers, gears and gear trains which play key role in in automobile, aerospace and allied engineering industries, industrial automation, design and construction of modern automatic machines.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Mechanism and Machine Design	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
2%	Understand
3%	Apply
1%	Analyze

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

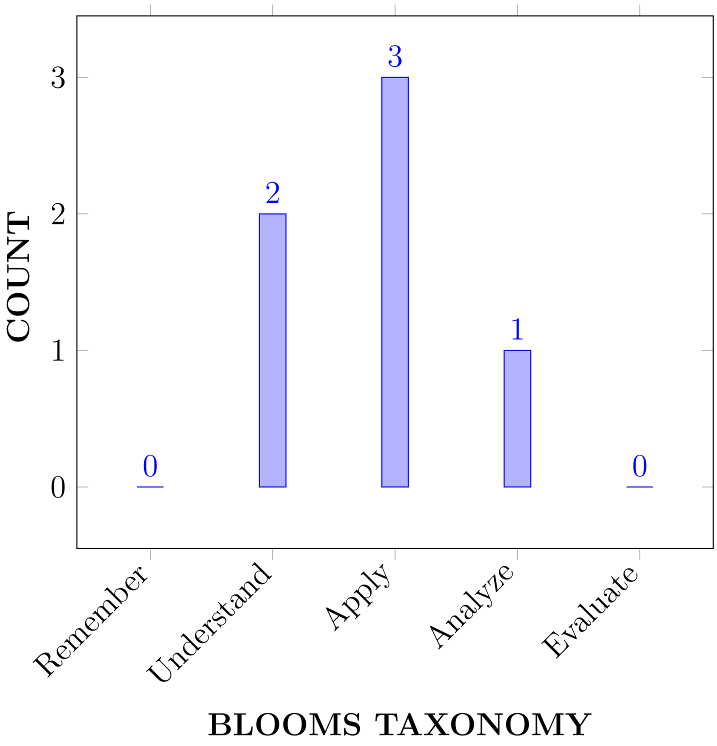
I	The concepts on four bar, single and double slider mechanisms and their inversions in analyzing the relative motions of links for engineering applications.
II	The kinematic analysis of planar mechanisms using instantaneous and relative velocity methods for describing the position, velocity and acceleration of moving links.
III	The effects of gyroscopic couples and rotating masses in designing of aircraft and machine components.
IV	The mechanisms of power transmission among the shafts using cams, belts, toothed gearing and Gear trains in aerospace and aligned engineering industries.

VII COURSE OUTCOMES:

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

CO 1	**Identify** the mechanisms and their inversions based on pairs and joints and mobility of mechanisms using Grumbler's and Grashaf's criterion for studying motion of machine elements in engineering applications.	Apply
CO 2	**Analyze** the planar mechanisms for position, velocity and acceleration using instantaneous center method and graphical approach.	Analyze
CO 3	**Choose** the uniform velocity, simple harmonic motion and uniform acceleration, maximum velocity and acceleration during outward and return strokes effect of gyroscopic precession on the stability of vehicles	Apply
CO 4	**Illustrate** the gear tooth geometry and appropriate gear train for power transmission at desired speeds and new design of gear boxes in engineering applications	Understand
CO 5	**Make use of** the effect of gyroscopic couple for stabilization of ship, Aero-plane, two and four wheeler vehicles during steering, pitching and rolling.	Apply
CO 6	**Explain** the methods for reducing undesirable effects of unbalanced masse, when rotating same or different planes using graphical and analytical methods when rotating same or different planes using graphical and analytical methods .	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards	3	Quiz
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	1	Quiz

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Demonstrate (knowledge) the principles of kinematic pairs, chains and their classification to a considerable extent appreciate (understanding) their importance and applicability for planar mechanisms based on pairs and joints by applying the principles of science and Engineering	2
	PO 2	Understand (given problem statement) the principles of kinematic pairs, chains and their classification, Degree of Freedom (complex) for planar mechanisms based on pairs and joints (provided information and data) in reaching substantiated conclusions by the interpretation of results	3
CO 2	PO 1	Identify (understanding) mechanisms and inversions of kinematic chins, and their mobility using Grumbler's and Grashaf's criterion for engineering applications (apply) in solving (complex) engineering problems by applying the principles of mathematics, science and engineering fundamentals.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Understand the (given problem statement) mechanisms and inversions of kinematic chins using Grumbler's and Grashaf's criterion for engineering applications (from the provided information and data) in solving problems of linkage mobility.	3
	PSO 2	Apply (knowledge) Identify the mobility of mechanisms and inversions of kinematic chains (apply) using Grumbler's and Grashaf's criterion for engineering applications by applying the principles of mathematics, science and Engineering	2
CO 3	PO 1	Analyze (understanding) the planar mechanisms for position, velocity and acceleration using instantaneous center method and graphical approach (complex) by applying the principles of mathematics and science	2
	PO 2	Understand (the given problem statement and formulate) the planar mechanisms for position, velocity and acceleration using instantaneous center method and graphical approach (from the provided information and data in reaching substantiated conclusions by the interpretation of results)	4
	PSO 2	Analyze (knowledge) the planar mechanisms for position, velocity and acceleration (apply) using instantaneous center method and graphical approach by applying the principles of mathematics, science and Engineering	3
CO 4	PO 1	Choose (understanding) appropriate belt drives for power transmission between the shafts based on follower rotation for industrial needs (complex) by applying the principles of mathematics, science and engineering fundamentals.	3
	PO 2	Choose the appropriate (given problem statement and formulate) belt drives for power transmission between the shafts based on follower rotation for industrial needs (provided information and data in reaching substantiated conclusions by the interpretation of results)	4
	PSO 2	Choose (knowledge) appropriate belt drives for power transmission between the shafts (apply) based on follower rotation for industrial needs by applying the principles of mathematics, science and Engineering	2
CO 5	PO 1	Identify (knowledge) the displacement diagram of follower and cam profile (apply) for the specified motions of the follower using cam terminologies (complex) by applying the principles of mathematics, science and Engineering	3
	PO 2	Understand (the given problem statement and formulate) the displacement diagram of follower and cam profile (from the provided information and data) for the specified motions of the follower (results) using cam terminologies	4

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 2	Identify (knowledge) the displacement diagram of follower and cam profile (apply) for the specified motions of the follower using cam terminologies by applying the principles of mathematics, science and Engineering	2
CO 6	PO 1	Analyze (understanding) speed and torque of simple, compound and epicyclic gear trains (apply) in designing (complex) gear boxes for real field applications by applying the principles of mathematics, science and engineering fundamentals.	3
	PO 2	Identify (the given problem statement and formulate) speed and torque of simple, compound and epicyclic gear trains (from the provided information and data)) for designing gear boxes (results) in real field applications	4

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	50	-	-	-	-	-	-	-	-	-	-	40	-	-
CO 2	100	50	40	-	-	-	-	-	-	-	-	-	-	-	50
CO 3	66.7	50	30	-	-	-	-	-	-	-	-	-	-	-	18
CO 4	100	50	50	-	-	-	-	-	-	-	-	-	-	-	18
CO 5	66.7	20	40	-	-	-	-	-	-	-	-	-	-	-	50
CO 6	66.7	50	-	-	-	-	-	-	-	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	MECHANISMS & MACHINES
	Elements of links, classification, rigid link, flexible and fluid link, types of kinematic pairs, sliding, turning, rolling, screw and spherical pairs, lower and higher pairs, closed and open pairs, constrained motion, completely, partially or successfully constrained, and incompletely constrained, mechanism and machines, classification, kinematic chain, inversion of mechanism, inversion of quadratic cycle, chain, single and double slider crank chains

MODULE II	**KINEMATIC ANALYSIS OF MECHANISMS**
	Instantaneous centre of rotation, centroids and axodes, relative motion between two bodies, three centres in line theorem, graphical determination of instantaneous centre, diagrams for simple mechanisms and determination of angular velocity of points and links. Velocity and acceleration, motion of link in machine, determination of velocity and acceleration diagrams, graphical method, application of relative velocity method for four bar chain, analysis of slider crank chain for displacement, velocity and acceleration
MODULE III	**BELT DRIVES, AND CAMS AND FOLLOWERS**
	Belt Drives: Types of Belts, Material used for Belts, Types of Flat Belt Drives, Velocity Ratio of Belt Drive. Length of Open Belt Drive. Power Transmitted by a Belt. Ratio of Driving Tensions for Flat Belt Drive. Centrifugal Tension. Maximum Tension in the Belt. Initial Tension in the Belt. Cams and followers, definition uses, types, terminology, types of follower motion, uniform velocity, simple harmonic motion and uniform acceleration, maximum velocity and acceleration during outward and return strokes. .
MODULE IV	**GEARS AND GEAR TRAINS**
	Gears And Gear Trains: friction wheels and toothed gears, types, law of gearing, condition for constant velocity ratio for transmission of motion, velocity of sliding, form of teeth, cycloidal and involute profiles, phenomena of interferences.Gear trains: Introduction, types, simple and reverted gear trains, epicyclic gear train; Methods of finding train value or velocity ratio of epicyclic gear trains
MODULE V	**GYROSCOPIC COUPLE AND PRECESSION MOTION AND BALANCING OF ROTATING MASSES**
	Angular Motion: Gyroscopes - Processional Angular Motion; Gyroscopic Couple; effect of precession motion on the stability of moving vehicles such as motorcycle - motorcar - aero planes and ships. Balancing of Rotating Masses;. Balancing of a Single Rotating Mass By a Single Mass Rotating in the same plane; Balancing of a Single rotating mass by two masses rotating in different planes; Balancing of several masses rotating in the same plane; Balancing of several masses rotating in different planes.

TEXTBOOKS

1. Amithab Ghosh, Asok Kumar Malik, "Theory of Mechanisms and machines", East West Press Pvt Ltd, 2001.

2. S.S Ratan, "Theory of Machines", Tata McGraw-Hill, 4th Edition, 2014.

3. J. S. Rao, R.V. Dukkipati "Mechanism and Machine Theory / New Age Publications", 1996.

4. P. L. Ballaney, "Theory of Machines", Khanna Publishers, 3rd Edition, 2003

REFERENCE BOOKS:

1. Dr Jagdish Lal, J. M. Shaw "Theory of Machines", 1st Edition, 1985.

2. Abdulla Sharif, Dhanpat Rai, "Theory of Machines", 5th Edition, 1987,

3. Neil Sclater, P. Nicholas, Chironis "Mechanisms and Mechanical Devices Sourcebook", New York McGraw-Hill, publications, 3rd Edition.1963

4. J. E. Shigley, R. Charles, Mischke,"Mechanical engineering and design", TMH,1st Edition, 2003.

WEB REFERENCES:
https://akanksha.iare.ac.in/index?route=course/detailscourse$_id = 432$

COURSE WEB PAGE:
https://akanksha.iare.ac.in/index?route=course/detailscourse$_id = 432$

XIX COURSE PLAN:
The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	https://lms.iare.ac.in/index?route=course/details and courseid=285
CONTENT DELIVERY (THEORY)			
1	Elements of links, classification, rigid link, flexible and fluid link	CO1	T1:1.2, R1:5.2
2	Types of kinematic pairs, sliding, turning, rolling, screw and spherical pairs	CO1	T1:1.3,1.4
3	Constrained motion, completely, Partially or successfully constrained Incompletely constrained,	CO1	T1:1.6, R1:5.6
4	mechanism and machines, Classification, kinematic chain, inversion of mechanism	CO1	T1:2.2
5	Inversion of quadratic cycle ,	CO2	T1:2.4, R1:6.2
6	Single slider crank chains,	CO2	T1:2.4, R1:6.2
7	Double slider crank chains	CO2	T1:2.4, R1:6.2
8	Instantaneous centre of rotation, centroids and axodes, relative motion between two bodies,	CO3	T1:2.8
9	Three centres in line theorem graphical determination of instantaneous centre,	CO3	T1:2.9, R1:6.8
10	Diagrams for simple mechanisms and determination of angular velocity of points and links	CO3	T1:3.2, R2:4.8
11	Velocity and acceleration, motion of link in machine	CO3	T1:3.4
12	velocity and acceleration diagrams	CO3	T1:3.5, R1:5.7
13	Relative velocity method for four bar chain	CO3	T1:3.9
14	Analysis of slider crank chain for displacement	CO3	T1:3.9, R2:4.12

15	Velocity and acceleration of sliding, acceleration diagram	CO3	T1:3.9, R2:4.12
16	Types of Belts, Material used for Belts, Types of Flat Belt Drives.	CO4	T1:7.1 T1:7.2
17	Velocity Ratio of Belt Drive, Length of an Open Belt Drive.	CO4	T1:7.5 T1:7.6
18	Power Transmitted by a Belt, Ratio of Driving Tensions for Flat Belt Drive.. Centrifugal Tension	CO4	T1:7.8, T1:7.9
19	Maximum Tension in the Belt and problems, Initial Tension in the Belt and problems	CO4	T1:7.10 T1:7.11
20	Cams and followers: Definition uses, types, terminology, types of follower motion	CO5	T1:8.1 T1:8.3, R1:7.2
21	Uniform velocity	CO5	T1:8.4, T1:8.8 R1:7.3
22	simple harmonic motion Uniform acceleration	CO5	T1:8.4, T1:8.8 R1:7.3
23	Maximum velocity and acceleration during outward and return strokes,	CO5	T1:8.9, R1:7.5
24	Gears: Types, law of gearing; Tooth profiles: Specifications, classification	CO6	T1:9.2, R1:8.2
25	Length of Path of Contact and problems	CO6	T1:9.4 R1:7.9
26	Length of Arc of Contact.	CO6	T1:9.6, R1:7.9
27	Contact Ratio, Interference in Involute Gears	CO6	T1:9.7, R2:7.8
28	Gear Trains, Simple Gear Train, Compound Gear Train..	CO4	T1:9.3
29	Reverted Gear Train. Epicyclic Gear Train.	CO4	T1:10.4, R2:7.9
30	Compound Epicyclic Gear Train (Sun and Planet Wheel).	CO4	T1:10.6
31	Compound Epicyclic Gear Train (Sun and Planet Wheel).	CO4	T1:9.5, R1:9.5
32	Compound Epicyclic Gear Train (Sun and Planet Wheel).	CO4	T1:9.6
33-34	Gyroscopes - Processional Angular Motion; Gyroscopic Couple;	CO6	T2:5.1
35	Effect of precession on the stability of airplanes	CO6	T2:5.3, R1:5.9
36	Effect of precession on the stability of ships	CO6	T2:5.4
37	Effect of precession on the stability of ships	CO6	T2:5.4
38	Effect of precession on the stability of for wheel vehicles,	CO6	T2:5.4, R2:4.9
39	Effect of precession on the stability of for wheel vehicles,	CO6	T2:5.4, R2:4.9
39	Effect of precession on the stability of motorbikes,	CO6	T2:5.7

40	Balancing of rotating masses Balancing of a Single Rotating Mass By a Single Mass Rotating in the Same Plane.	CO5	T2:21,1 R2:7.2
41	Balancing of rotating masses Balancing of a Single Rotating Mass By a Single Mass Rotating in the Same Plane.	CO5	T2:21,1 R2:7.2
42	.Balancing of a Single Rotating Mass By Two Masses Rotating in Different Planes	CO5	T2:21.2
43	Problems on Balancing of a Single Rotating Mass By Two Masses Rotating in Different Planes	CO5	T2:21.3
44	Balancing of Several Masses Rotating in the Same Plane..	CO5	T2:22.4
45	Balancing of Several Masses Rotating in Different Planes.	CO5	T2:22.5
PROBLEM SOLVING/ CASE STUDIES			
46	Inversion of quadratic cycle	CO2	T1:2.4, R1:6.2
47	Single slider crank chains,	CO2	T1:2.6, R1:6.5
48	Graphical method: Velocity diagrams	CO3	T1:2.9, R1:6.8
49	Relative method: Velocity and acceleration diagrams	CO3	T1:3.9, R2:4.12
50	Belt Drives: Power Transmitted by a Belt,	CO4	T1:7.5 T1:7.6
51	Cams and follower: Uniform velocity, simple harmonic motion Uniform acceleration	CO5	T1:8.4, T1:8.8 R1:7.3
52	Toothed gearing: Length of Arc of Contact and contact ratio	CO6	T1:9.6, R1:7.9
53	Reverted Gear Train. Epicyclic Gear Train.	CO4	T1:10.4, R2:7.9
54	Effect of precession on the stability of airplanes and naval ships	CO6	T2:5.3, R1:5.9
55	Problems on Balancing of a Single Rotating Mass By Two Masses Rotating in Different Planes	CO5	T2:22.4
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Mechanisms & Machines	CO1, CO2	T1:2.4, R1:6.2
57	Kinematic Analysis of Mechanisms	CO3	T1:3.9, R2:4.12
58	Belt Drives and Cars and Followers	CO4,CO5	T1:7.5 T1:7.6
59	Gears and Gear Trains	CO6,CO4	T1:9.6, R1:7.9
60	Gyroscopic Couple abd Precession Motion	CO6, CO5	T2:5.3, R1:5.9 T2:22.4
DISCUSSION OF QUESTION BANK			
61	Mechanisms & Machines	CO1, CO2	T1:2.4, R1:6.2

62	Kinematic Analysis of Mechanisms	CO3	T1:3.9, R2:4.12
63	Belt Drives and Cars and Followers	CO4,CO5	T1:7.5, T1:7.6
64	Gears and Gear Trains	CO6	T1:9.6, R1:7.9
65	Gyroscopic Couple abd Precession Motion	CO6	T2:5.3, R1:5.9 T2:22.4

Course Coordinator **HOD,AE**
Mr V Raghavender, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

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

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

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

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

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

Signature of Course Coordinator **HOD,AE**

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**RELATIONAL DATA BASE MANAGEMENT SYSTEM**				
Course Code	ACSB34				
Program	B.Tech				
Semester	VI				
Course Type	ELECTIVE				
Regulation	R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	1	3	-	-
Course Coordinator	Ms. K RASHMI,Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS003	I	Computational Mathematics and Integral Calculus

II COURSE OVERVIEW:

The purpose of this course is to provide a clear understanding of fundamentals with emphasis on their applications to create and manage large data sets. It highlights on technical overview of database software to retrieve data from n database. The course includes database design principles, normalization, concurrent transaction processing,, security, recovery and file organization techniques

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Discrete Mathematical Structures	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
40 %	Understand
50 %	Apply
0 %	Analyze
0 %	Evaluate
0 %	Create

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

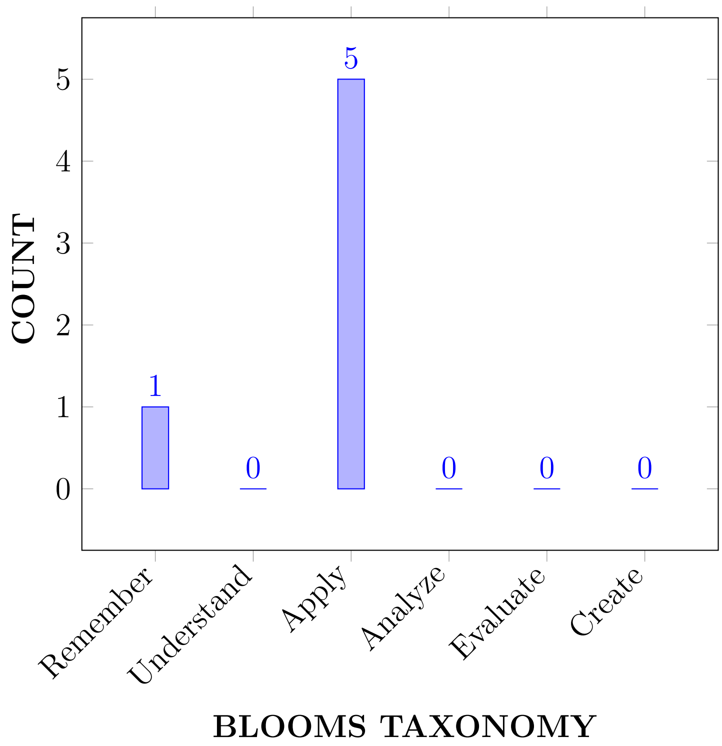
I	Acquire analytical thinking and identify efficient ways of designing database by encapsulating data requirements for business and organizational scenarios.
II	Develop expertise in database language SQL to develop sophisticated queries to extract information from large datasets.
III	Enhance skills to develop and manage data in solving related engineering problems.

VII COURSE OUTCOMES:

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

CO 1	**Outline** the importance of database system and its functionalities using entity relationship model for data storage and management.	Remember
CO 2	**Illustrate** basic and relational operations to access data from the database.	Apply
CO 3	**Build** SQL queries for database creation, manipulation and data retrieval.	Apply
CO 4	**Identify** the appropriate normalization technique for controlling the redundancy of database.	Apply
CO 5	**Demonstrate** the ACID properties of transaction processing to preserve the database in a consistent state.	Apply
CO 6	**Make use of** concurrency control protocols to provide the congestion free transactions of data.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	**Understand, design and analyze** computer programs in the areas related to Algorithms, System Software, Web design, Big data, Artificial Intelligence, Machine Learning and Networking.	3	SEE/AAT

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 3	**Make use of** modern computer tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2	SEE/AAT

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Define database, characteristics, functions of database management system and types of users to describe large sets of data with knowledge of mathematics, and Engineering Fundamentals..	2
CO 2	PO 1	Compare traditional File Processing System and a Database System for constructing a database using the knowledge of mathematics, science, and engineering fundamentals.	3
	PO 2	Compare traditional File Processing System and a Database System for constructing a database With Problem statement and system definition , Problem formulation and abstraction .	7
CO 3	PO 1	Describe data models, schemas, instances, view levels and database architecture for voluminous data storage using principles of mathematics, science, and engineering fundamentals.	3
	PO 2	Describe data models, schemas, instances, view levels and database architecture for voluminous data storage with Problem statement and system definition , Problem formulation and abstraction	2
CO 4	PO 2	Model the real world database systems using Entity Relationship Diagrams from the requirement specification with the Problem statement and system definition, Problem formulation and abstraction , Information and data collection, Model translation.	4

	PO 3	Model the real world database systems using Entity Relationship Diagrams from the requirement specification through Investigate and define a problem and identify constraints ,Understand customer and user needs, Manage the design process and evaluate outcomes.	4
	PO 4	Model the real world database systems using Entity Relationship Diagrams from the requirement specification by Understanding of contexts in which engineering knowledge can be applied, Understanding use of technical literature, Understanding of appropriate codes of practice and industry standards.	3
	PSO 1	Model the real world database systems using Entity Relationship Diagrams from the requirement specification by using sequence of steps.	1
CO 5	PO 1	Define the relational data model, its constraints and keys to maintain integrity of data using the knowledge of mathematics, science, and engineering fundamentals.	3
	PO 2	Define the relational data model, its constraints and keys to maintain integrity of data with the Problem statement and system definition, Problem formulation and abstraction , Information and data collection, Model translation.	4
CO 6	PO 1	Define the concept of Relational Algebra and Relational Calculus from set theory to represent queries with knowledge of mathematics, science and engineering fundamentals for capacitance calculation.	3

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100.0	60.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	37.5	66.66	0.0	50.0
CO 2	100.0	70.0	60.0	72.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	37.5	66.66	0.0	50.0
CO 3	100.0	80.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	37.5	66.66	0.0	50.0

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 4	100.0	60.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	37.5	66.66	0.0	50.0
CO 5	100.0	80.0	80.0	72.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	37.5	66.66	0.0	50.0
CO 6	100.0	80.0	80.0	72.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	37.5	66.66	0.0	50.0

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**CONCEPTUAL MODELING INTRODUCTION**
	Introduction to Databases and Database Management System - Database system Applications Advantages of DBMS over File System - Data Models – Instances and schema - View of Data - Database Languages - DDL-DML - Database Users and Administrator - Database System Structure.
MODULE II	**RELATIONAL APPROACH**
	Database Design and ER diagrams – Attributes and Entity Sets – Relationships and Relationship Sets – Constraints - Keys - Design Issues - Entity-Relationship Diagram- Weak Entity Sets - Extended E-R Features- Database Design with ER model - Database Design for Banking Enterprise.
MODULE III	**SQL QUERY - BASICS, RDBMS - NORMALIZATION**
	SIntroduction to the Relational Model – Structure of RDBMS - Integrity Constraints over Relations – Enforcing Integrity Constraints – Querying Relational Data - Relational Algebra and Calculus. Introduction to SQL- Data Definition commands, Data Manipulation Commands, Basic Structure, Set operations Aggregate Operations - Join operations - Sub queries and correlated queries, SQL functions, views, Triggers, Embedded SQL.
MODULE IV	**TRANSACTION MANAGEMENT**
	Functional Dependencies– Introduction , Basic Definitions, Trivial and Non trivial dependencies, closure of a set of dependencies, closure of attributes, irreducible set of dependencies- Schema Refinement in Database Design- Problems Caused by Redundancy Decompositions – Problem Related to Decomposition — Lossless Join Decomposition – Dependency Preserving Decomposition - FIRST, SECOND, THIRD Normal Forms – BCNF –Multi valued Dependencies – Fourth Normal Form.
MODULE V	**DATA STORAGE AND QUERY PROCESSING**
	Transaction concept- Transaction state- Implementation of atomicity and Durability- Concurrent executions – Serializability, Recoverability; File Organization – Organization of records in file - Data Dictionary Storage – Indexing and Hashing – Basic Concepts , Ordered Indices,B+Tree Index files, B- tree index files.

TEXTBOOKS

1. Abraham Silberschatz, Henry F. Korth, S. Sudarshan, "Database System Concepts", McGraw-Hill 6th Edition, 2017.

REFERENCE BOOKS:

1. Ramez Elmasri, Shamkant B. Navathe, "Fundamental Database Systems", Pearson Education, 6th Edition, 2014. 2. Raghu Ramakrishnan, "Database Management System", Tata McGraw
2. Hector Garcia Molina, Jeffrey D. Ullman, Jennifer Widom, "Database System Implementation", Pearson Education, United States, 1st Edition, 2000.
3. Peter Rob, Corlos Coronel, "Database System, Design, Implementation and Management", Thompson Learning Course Technology, 5th Edition, 2003.

WEB REFERENCES:

1. http://www.web.stanford.edu/class/cs103x
2. http://www.saylor.org/course/cs202/.
3. http://www.cse.iitd.ernet.in/ bagchi/courses/discrete-book

COURSE WEB PAGE:

1. https://lms.iare.ac.in/index ?route=course/details& course id=84

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	https://lms.iare.ac.in/index ?route=course/details& course id=84
CONTENT DELIVERY (THEORY)			
2-3	Introduction, Data base System Applications, Purpose of data base Systems, View of Data – Data Abstraction, Instances and Schemas Data Models,, Database Languages, Data base access for applications Programs	CO 1, ,CO 2	T2: 1.1- 1.5
4-6	Transaction Management component of DB architecture, Data base users, History of database systems, Database design, ER Diagrams.	CO 3, CO 4	T2: 1. 6 - 1.8,, 1.10,T1: 2.1
7	Entities, Attributes and entity sets, Relationships and relationship sets, Additional features of ER model, Conceptual design with ER model, Conceptual design for large enterprises	CO 1	T2: 1. 6 - 1.8,, 1.10,T1: 2.1

8– 14	Relational Model: Introduction to the Relational Model – Integrity Constraint Over relations, Enforcing Integrity constraints – Querying relational data	CO 5	T1:1.5, 1.4.2,1.4.3
15-20	Relational Algebra and Calculus: Relational Algebra – Selection and projection –set operations – renaming, Joins – Division	CO 2,CO 6	T1:1.4.3, 1.4.4,2.3.1, 2.3.2,2.3.6,2.3.7,2.3.8
21-25	Relational calculus – Tuple relational Calculus – Domain relational calculus – Expressive Power of Algebra and calculus.	CO 2	R2:4.3 T1:2.4.1, 2.4.2,2.4.3, 4.1
26-29	Form of Basic SQL Query – Examples of Basic SQL Queries Comparison Operators – Aggregative Operators, NULL values , Logical connectivity's – AND, OR and NOT, complex Integrity Constraints in SQL	CO 2,CO 3,CO 6	T1:3.1,3.2 R1:6.2-6.8
30-35	Introduction to Nested Queries – Correlated Nested Queries Set Comparison Operators – Aggregative Operators, Triggers and Active Data bases.	CO 3 ,CO 6	R1: 7.1-7.6
36-38	Introduction to Schema refinement – Problems Caused by redundancy ,Decompositions – Problem related to decomposition	CO 3,CO 6	R2:8.1
39-44	Functional dependencies, reasoning about FDS ,Lossless join Decomposition , Dependency preserving Decomposition	CO 3	R2:8.2, 8.3
45-48	Schema refinement in Data base Design, Normal Forms, MVDs, JDs	CO 4,CO 6	R2: 9.1-9.3
49-54	Transaction Management: Transaction Concept-Transaction State- Implementation of atomicity and Durability, Concurrent Executions, Serializability , Recoverability, Implementation of Isolation, Testing for Serializability.	CO 4	R2: 9.8, 9.9, 10.1, 10.2
55-59	Concurrency Control: Lock-Based Protocols –time Stamp Based protocols-,Validation Based Protocols-Multiple Granularity	CO 5,CO 6	T2:5.5, 5.9, 5.10
60	Recovery System-Failure Classification-storage Structure recovery and Atomicity-Log Based Recovery.Tree Structured Indexing: B+ Trees, Hashing	CO 5,CO 6	R2:10.4, 10.6,10.7
PROBLEM SOLVING/ CASE STUDIES			
1	Entity Sets and Attributes	CO1,CO 6	T2:2.1
2	Degree and Cardinality constraints of relationship	CO1	T2:2.3
3	Distributed Query Processing – Case Studies	CO1,CO 6	T2:2.3.1
4	Aggregation – Role in ER Model	CO 2	T2:7.2,7.3
5	Syntax and Semantics of Data log Languages	CO 2,CO 6	T2:10.3.1
6	Rules to convert ER model into relational models (Entity sets)	CO 2,CO 6	T2:13.3.2, 13.4.1
7	Triggers – Introduction	CO 2	T2:17.1.1, 17.1.3
8	Closure of Set of FDs	CO 2,CO 6	T2:18.3.4, 18.3.4.1

9	Update, insert and Delete Anomalies	CO 3	T2:22.12, 19.1.2
10	Join Dependencies and 5NF .	CO 3,CO 6	T2:18.4, 18.4.3
11	Cloud Storage Architectures-Cloud Data Models	CO 5,CO 6	T2:19.2, 18.4.4
12	SAP as an Applications of databases	CO 5,CO 6	T2:23.1.1, 23.1.3
DISCUSSION ON DEFINITION AND TERMINOLOGY			
1	Define Database Management System?	CO 1,CO 6	T2:18.3.4, 18.3.4.1
2	What is Hierarchical model?	CO 2,CO 6	T2:22.12, 19.1.2
3	Compare Logical data independence and physical data independence?	CO 3,CO 6	T2:18.4, 18.4.3
4	What are natural join operations?	CO 4,CO 6	T2:19.2, 18.4.4
5	Define Functional Dependency?	CO 5, CO6	T2:23.1.1, 23.1.3
DISCUSSION ON QUESTION BANK			
1	Why relational model became more popular comparing with other record based models?	CO 1, CO 2	T2:18.3.4, 18.3.4.1
2	Illustrate different set operations in Relational algebra with an example.	CO 2, CO 6	T2:22.12, 19.1.2
3	Define a View in SQL. Write about updates on views.	CO 3, CO6,	T2:18.4, 18.4.3
4	Explain ACID properties and Illustrate them through examples?	CO4, CO 6	T2:19.2, 18.4.4
5	Why do you need concurrency in Transactions?	CO 5, CO 6	T2:23.1.1, 23.1.3

Course Coordinator **HOD,AE**
Mrs K Rashmi,Assistant Professor

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

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**AVIONICS AND INSTRUMENTATION**				
Course Code	AAEB45				
Program	B.Tech				
Semester	VII	AE			
Course Type	Elective				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms.Madhurakavi Sravani , Assistant Professor				

I COURSE OVERVIEW:

Avionics deals with electronic systems which are used on aircraft, satellites and spacecrafts. This course introduces the major phases of avionics from the basic navigation, guidance, and communication to sophisticated systems comprising of state of art sensors and radars used in aerospace systems. The course introduces various electronic instrument systems, numbering systems, data buses, data conversion and logic gates and provides an understanding of the sensors, display system and communication system for various aerospace applications. The course also discusses advanced avionics systems and different adaptations involved in a military aircraft.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAE010	V	Aircraft Systems And Control
B.Tech	AAE001	V	Aircraft Performance

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Avionics And Instrumentation	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	The fundamental principles of sensors, radars, radio communication and navigation systems and their application.
II	Concept of microelectronic devices along with their evolution and applications, with the emphasis on digital data buses.
III	Learn the advances in modern avionics systems, and their application in military and civil aircrafts.

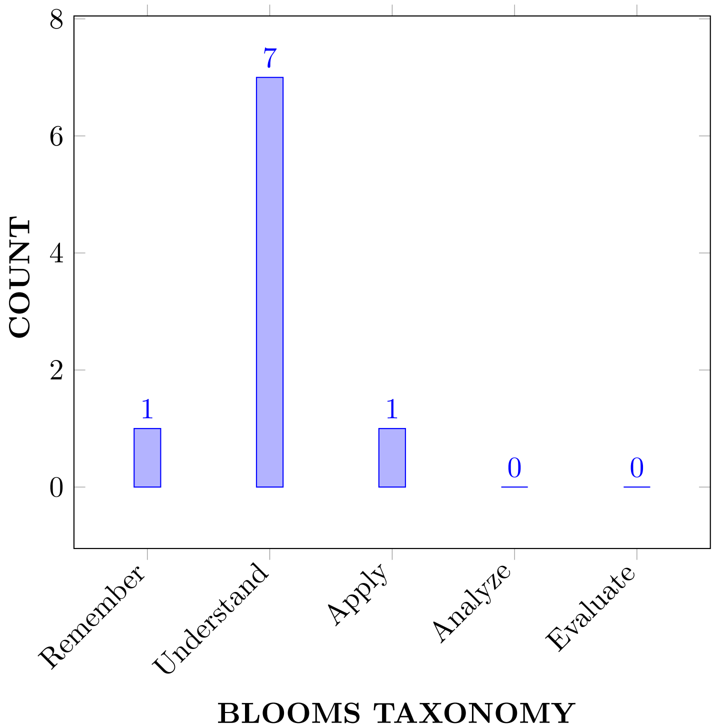
VII COURSE OUTCOMES:

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

CO 1	**List** various electronic instrument systems and avionics systems integration for the design of modem aircraft.	Remember
CO 2	**Illustrate** the fundamental principles of various types of sensors for to monitor the parameters in an aircraft.	Understand
CO 3	**Illustrate** the working principles of various flight instruments in flight deck for monitoring status of the flight in one integrated display.	Understand
CO 4	**Explain** the basic principle and various types of navigation systems to provide accurate position of a moving aircraft relative to earth.	Understand
CO 5	**Explain** the concept of various navigational aids that guide the pilot to land the aircraft safely on a runway.	Understand

CO 6	**Demonstrate** the major methods of countering detection and impairing the effectivenes of an enemy's fire control solution.	Understand
CO 7	**Identify** Hardware units, working principle, Environmental effects and applications of Airborne Radar for detect the enemy aircraft.	Apply
CO 8	**Explain** the optical attitude measuring instruments for monitored throughout its on-orbit operation.	Understand
CO 9	**Illustrate** the radiation characteristics of micro strip antennasusing electric field distribution on aircraft and missiles.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	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 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	SEE/ CIE, AAT, QUIZ

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards	3	Quiz
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	1	Quiz

3 = High; 2 = Medium; 1 = Low

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

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

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** to classify various rocket propulsion systems and missiles	3
	PO 2	**Identify the problem statement** (mission requirement), select the appropriate missile required for destroying target by reviewing the literature (information and data collection) suitable to mission requirement	2
CO 2	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** and derive the rocket thrust equation under different flight conditions	3
	PO 2	Analyze the performance parameters of rocket and various forces acting on a rocket using **first principles of Mathematics and engineering sciences.**	2
CO 3	PO 1	Identify various chemical rocket propulsion systemsand its propellants **using principles of mathematics, science, and engineering fundamentals.**	3
CO 4	PO 1	Apply the knowledge of different forces (**scientific Principles and mathematical principles**) for chemical rocket engine and describe different performance parameters.	3
	PO 2	Determine the grain parameters and rocket performance parameters **using first principles and Mathematics and Engineering sciences.**	2
	PO 5	Illustrate Thrust vs time graph of solid rocket motor using modern Engineering and IT tools (Matlab) to **solve complex engineering problems.**	1
CO 5	PO 1	Understand the advantages of solid propellant, monopropellant and Bi-propellant to determine the desirable properties of oxidizer, Inert gas and fuel **using the fundamentals of engineering and mathematical equations**	3
CO 6	PO 1	Analyze different Engine cycles used for propulsion system of a chemical rocket engine **using fundamentals of science &and engineering fundamentals.**	3
	PO 2	Categorize the concept of Pyrotechnics based on its physical state and its usage in **complex engineering problems.**	3
CO 7	PO 1	Understand (**knowledge**) different combustion instabilities w.r.t time for various chemical rocket engines during flight by **applying the knowledge of sciences and Engineering fundamentals principles**	3

	PSO 1	**Synthesize** and **analyze** different combustion systems for non-air breathing engines to provide thrust for the Rockets and missiles	2
CO 8	PO 1	Describe (**Knowledge**) different guidance phases and guidance systems for a cruise and ballistic missile **using principles of mathematics, natural science, and engineering fundamentals.**	3
	PSO 2	Extend the focus to **understand the innovative and dynamic challenges** involve the guidance system of rocket and missiles for specific role.	1
CO 9	PO 1	Evaluate the performance characteristics of single stage and multistage rocket using the basic **understanding of engineering science and mathematical equations**	3
	PO 2	**Identify the problem statement** (mission requirement), select the number of stages required for placing a payload into the orbit by reviewing the literature (**information and data collection**) suitable to mission requirement	2
	PO 12	Understand the usage of modern avionics systems to engage in independent and (**life-long learning.**)	1

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

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

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

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	20	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	20	-	-	-	-	-	-	-	-	-		-	-	-
CO 5	66	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	10	-	-	-	-	-	-	-	-	-		-	-	-
CO 7	66	-	-	-	-	-	-	-	-	-	-	-	-		-
CO 8	100	-	-	-	-	-	-	-	-	-	-	-	-	50	-
CO 9	66	10	-	-	-	-	-	-	-	-	-	12	-	-	-
CO 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 11	-	-	-	-	-	-	-	-	-	-	-	-	-		-
CO 12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	2	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	-	-		-	-	-
CO 5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	1	-	-	-	-	-	-	-	-	-		-	-	-
CO 7	2	-	-	-	-	-	-	-	-	-	-	-	-		-
CO 8	3	-	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 9	2	1	-	-	-	-	-	-	-	-	-	1	-	-	-
CO 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 11	-	-	-	-	-	-	-	-	-	-	-	-	-		-
CO 12	-	-	-	-	3		-	-	-	-	2	-	-	-	-
TOTAL	23	8	-	-	-	-	-	-	-	-	-	1	-	1	-
AVERAGE	2.55	1.6	-	-	-	-	-	-	-	-	1	-	-	1	-

XV ASSESSMENT METHODOLOGY DIRECT:

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

XVI ASSESSMENT METHODOLOGY INDIRECT:

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

XVII SYLLABUS:

MODULE I	**AVIONICS TECHNOLOGY**
	Evolution of electronics; The nature of microelectronic devices, processors, memory devices; Introduction to avionics, systems integration, need - data bus systems, MIL STD 1553 bus system, ARINC 429/ARINC 629 bus systems, optical data bus systems; Integrated modular avionics architectures , commercial off the shelf systems; Avionics packaging.
MODULE II	**AIRCRAFT INSTRUMENTATION - SENSORS AND DISPLAYS**
	Air data sensors, magnetic sensing, inertial sensing, and radar sensors. The electromechanical instrumented flight deck, early flight deck instruments, attitude direction indicator, horizontal situation indicator,altimeter, airspeed indicator; Advanced flight deck display system architectures, display systems, display media, future flight deck displays.
MODULE III	**COMMUNICATION AND NAVIGATION AIDS**
	Radio frequency spectrum, communication systems, HF, VHF, satellite communications; ATC transponder, traffic collision avoidance system; Navigational aids; Automatic direction finding, VHF Omni range, distance measuring equipment; TACAN, VORTAC; Satellite navigation systems, the GPS. Basic navigation, radio, inertial navigations, satellite navigation; GPS, differential GPS, wide area augmentation systems, local area augmentation system, and GPS overlay program; Integrated navigation, sensor usage; Flight management system (FMS); FMS control and display MODULE; Lateral navigation.
MODULE IV	**MILITARY AIRCRAFT ADAPTATION**

	Avionic and mission system interface, navigation and flight management; Navigation aids, flight deck displays, communications, aircraft systems; Applications, personnel, material and vehicle transport, air-to-air refueling, maritime patrol, airborne early warning, ground surveillance; Electronic warfare, the EW spectrum, electronic support measures, electronic countermeasures, electro-optics and the infra-red.
MODULE V	**AIRBORNE RADAR, ASTRIONICS - AVIONICS FOR SPACECRAFT**
	Propagation of Radar waves, functional elements of radar, antenna-transmitter; Types of radar- pulse Doppler, civil aviation applications, military applications; Attitude determination and control of spacecraft, magnetometers, sun sensors, star trackers, earth and horizon sensors; Command and telemetry.

TEXTBOOKS

1. 1. Moir, I. and Seabridge, A., Civil Avionics Systems, AIAA Education Series, AIAA, 2002.
2. 2. Collinson, R.P.G., Introduction to Avionics Systems, second edition, Springer, 2003.

REFERENCE BOOKS:

1. 1. Helfrick, A., Principles of Avionics, Avionics Communications Inc. Leesburg, 2000.
2. 2. Henderson, M. F., Aircraft Instruments & Avionics for A &P Technicians, Jeppesen Sanderson Training Products, 1993.

XVIII COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
1-2	Evolution of electronics; The nature of microelectronic devices	CO 1	T1 : 1.1, 1.2,1.3,1.4
3	processors, memory devices	CO 1	T1 : 2.2
4-5	Introduction to avionics, systems integration	CO 1	T1: 2.3-2.4
6-9	Need - data bus systems, MIL STD 1553 bus system	CO 1	T2: 2.5-2.6,2.7
10-11	ARINC 429/ARINC 629 bus systems, optical data bus systems	CO 1	T1 : 2.9, 2.10
12-13	Integrated modular avionics architectures	CO 2	T1 : 2.10
14	Commercial off the shelf systems; Avionics packaging	CO 2	T1 : 3.4
15-16	Air data sensors, magnetic sensing	CO 12	T2: 5.1
17	Inertial sensing and radar sensors	CO 6	T2: 5.2
18	The electromechanical instrumented flight deck, early flight deck instruments	CO 3	T2: 4.5
19	Attitude direction indicator, horizontal situation indicator, altimeter	CO 3	T1: 4.1
20-21	Airspeed indicator; Advanced flight deck display system architectures	CO 7	T1: 4.2

22	Display systems, display media, future flight deck displays	CO 4	T1: 4.3
23-24	Radio frequency spectrum, communication systems, HF, VHF, satellite communications	CO 8	T1 : 4.4
25	ATC transponder, traffic collision avoidance system	CO 2	T2 : 3.3.1-3.3.4
26-27	Navigational aids; Automatic direction finding, VHF Omni range, distance measuring equipment	CO 9	T1 : 4.5
28-29	TACAN, VORTAC; Satellite navigation systems, the GPS.	CO 9	R1 : 6.1
30	Basic navigation, radio, inertial navigations, satellite navigation	CO 6	R1 : 6.1.1, 6.1.3
31	GPS, differential GPS, wide are augmentation systems,	CO 5	R1 : 6.1.3, 6.1.4
32	local area augmentation system, and GPS overlay program	CO 4	R1 : 6.2/ R2 : 11.6
33	Integrated navigation, sensor usage; Flight management system (FMS)	CO 8	T1 : 6.2, 6.3, 4.4/ R2 :6.6.2,6.6.3, 6.6.2.3
34	FMS control and display MODULE; Lateral navigation	CO 9	T1 : 6.5, 6.6, 6.7
35	Avionic and mission system interface, navigation and flight management	CO 9	T1 : 6.8
36	Navigation aids, flight deck displays, communications, aircraft systems	CO 9	T1 : 6.8.2, 6.8.3 / R1 :6.6
37	Applications, personnel, material and vehicle transport,	CO 8	R : 6.4, 6.6, 6.7, 6.8 / R1 : 6.7,6.8
38	Air-to-air refueling, maritime patrol, airborne early warning	CO 9	R : 6.4, 6.6, 6.7, 6.8 / R1 : 6.7,6.8
39	Ground surveillance; Electronic warfare, the EW spectrum	CO 9	T1 : 6.8.6
40	Electronic support measures, electronic countermeasures	CO 9	R1 : 5.1
41	Electro-optics and the infra-red.	CO 9	R1 : 5.2
42	Propagation of Radar waves, functional elements of radar	CO 9	R1 : 5.2.2, 5.2.3
43	Antenna- transmitter; Types of radar- pulse Doppler,	CO 9	R1 : 5.3.1

Signature of Course Coordinator **HOD,AE**
Ms.Madhurakavi Sravani,Assistant Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	AEROSPACE STRUCTURAL DYNAMICS LABORATORY				
Course Code	AAEB27				
Program	B.Tech				
Semester	VII	AE			
Course Type	CORE				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Dr Aravind Rajan Ayagara, Associate Professor				

I COURSE OVERVIEW:

Structural Dynamics is defined as that branch of engineering science, which deals with the study of relative motion between various parts of a machine and forces which acts on them. The knowledge is very essential for engineer in designing Various parts of a machine.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AAEB14	V	Analysis of Aircraft Structures	3.0
UG	AAEB11	IV	Aircraft Structures Laboratory	1.5

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Aerospace Strutural Dynamics Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Probing Further Experiments (last)	✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI HOW PROGRAM OUTCOMES ARE ASSESSED:

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

PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises/CIA/SEE
PO 9	**Individual and team work:**Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Lab Exercises/CIA/SEE

3 = High; 2 = Medium; 1 = Low

VII HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

VIII COURSE OBJECTIVES:

The students will try to learn:

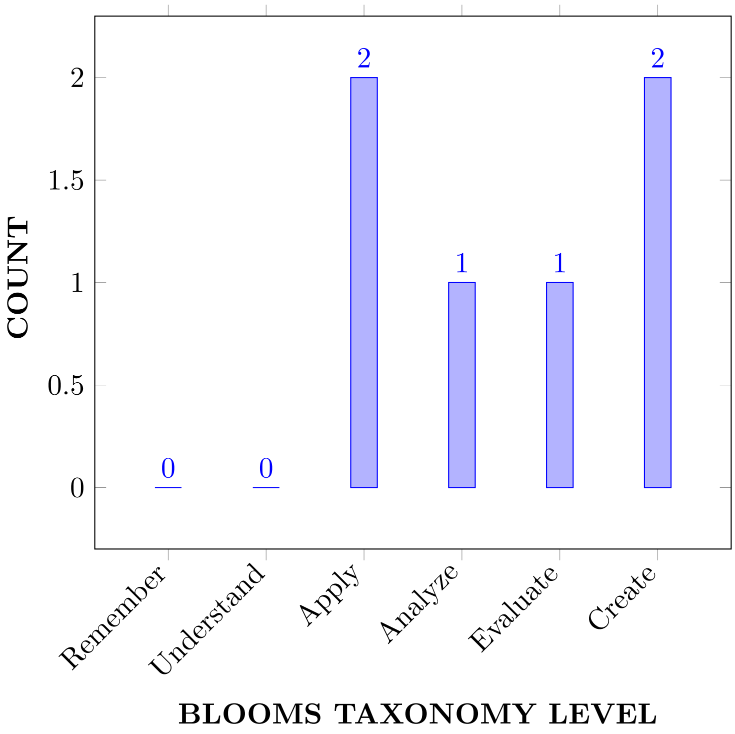
I	The Importance of theory of machines and mechanism involved in the day-to-day life, and study of basic mechanisms and inversion mechanisms to form a machine.
II	The information related design and analysis of mechanisms for a specific type of motion in a machine.
III	The developmental use of rigid bodies motions and forces for transmission system, machine kinematics.

IX COURSE OUTCOMES:

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

CO1	**Identify** the gyroscopic effect for the real time applications of ships, aero planes .	Apply
CO2	**Examine** the life expectancy for ball bearing and their real time application.	Analyze
CO3	**Select** the appropriate journal bearing for balancing of machine components such as shafts.	Apply
CO4	**Build** out the inversion mechanism for 4-bar mechanism to form different mechanical compoenents.	Evaluate
CO5	**Design** the shafts material for calculate the critical speed of shafts	Create
CO6	**Choose** the balancing techniques for effective balancing of machines and structures.	Create

COURSE COURSE KNOWLEDGE COMPETENCY LEVEL:



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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and engineering fundamentals.	2
e	PO 2	Understand the given **problem statement and apply data validation techniques to solve** (complex) specific engineering problems related to making of governors	3
CO 2	PO 1	Identify (knowledge) in suitable methods involved during welding for error free components using in solving (complex) engineering problems by applying the principles of **mathematics and engineering fundamentals**	2
	PO 2	Understand the given **problem statement and apply data validation techniques to solve** (complex) specific engineering problems related to welding in identification of process adoption for the specially develop component.	3
CO 3	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals.**	2

	PO 5	Create, select, and apply metal forming techniques, resources, and modern **engineering tools** including prediction and modeling to **complex engineering activities** with an understanding of the limitations.	2
CO 4	PO 1	Recall (knowledge) the basic molding processes uses plastics and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals.**	2
	PSO 3	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 5	PO 1	Identify (knowledge) in suitable methods involved in design, casting to achieve error free components using in solving (complex) engineering problems by applying the principles of **mathematics and engineering fundamentals**	2
	PO 5	Design the ball bearing and estimation of life, and **modern engineering tools** including prediction and modeling to **complex engineering activities** with an understanding of the limitations.	2
	PO 9	Design and develop the journal bearing effectively as an individual, and as a member in **diverse teams, and in multidisciplinary** settings for different lubricant effectively in building of product.	2
CO 6	PO 1	Recall (knowledge) the basic concepts of manufacturing processes and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals** for better solution.	2
	PO 5	Create, select, and apply appropriate mechanisms parameters, resources, and modern **engineering tools** including prediction and modeling to **complex engineering activities** with an understanding of the limitations for effective optimization of prototype / products.	2
	PSO 3	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PROGRAM OUTCOMES				Program Specific Outcomes
	PO 1	PO 2	PO 5	PO 9	PSO 3
CO 1	2	3			
CO 2	2	3			
CO 3	2		2		
CO 4	2				2
CO 5	2		2	2	
CO 6	2		2		2

3 = High; 2 = Medium; 1 = Low

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1, PO 2	SEE Exams	PO 1, PO 2, PO 5, PO 9 PSO 3	Seminars	-
Laboratory Practices	PO 1, PO 2, PO 5, PO 9	Student Viva	PO 1,PO 2, PO 5,PO 9	Certification	-
Assignments	PO 5, PO 9, PO 3	Mini projects	-		

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK 1	**GOVERNOR**
	To study the function of a Governor
WEEK 2	**GYROSCOPE**
	To determine the Gyroscope couple.
WEEK 3	**STATIC FORCE ANALYSIS**
	To draw free body diagram and determine forces under static condition.
WEEK 4	**DYNAMIC FORCE ANALYSIS**
	To draw free body diagram and determine forces under dynamic condition.

WEEK 5	**BALANCING**
	To determine balancing forces and reciprocating masses.
WEEK 6	**JOURNAL BEARING**
	To determine the bearing life.
WEEK 7	**UNIVERSAL VIBRATION**
	To determine the longitudinal and transfer vibration.
WEEK 8	**WHIRLING OF SHAFT**
	To determine critical speed of a shaft.
WEEK 9	**MECHANISMS**
	To design various mechanism and their inversions.
WEEK 10	**DIFFERENTIAL GEAR BOX**
	To study automobile differential gear box.
WEEK 11	**Indexing**
	To study various intermittent mechanism.
WEEK 12	**BEYOND SYLLABUS**
	To study various intermittent mechanism
WEEK 13	**EXAMINATIONS**

TEXTBOOKS

1. Thomas Bevan, "Theory of Machines", Pearson Education, 3rd Edition, 2009.
2. . S.S Ratan, "Theory of Machines", Tata McGraw-Hill, 4th Edition, 2014.

REFERENCE BOOKS:

1. J. S. Rao, R.V. Dukkipati, "Mechanism and Machine Theory", New Age Publication, 1st Edition, 2013.
2. Uiker, Penock, Shigley, "Theory of Machines and Mechanisms", Oxford University Press, 4th Edition, 2013.
3. R.S. Khurmi, Guptha, "Theory of Machines", S.Chand & Co, New Delhi, 14th Edition, 2013.

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Governor	CO1, CO 5	T1:2.1.5 T2:2.3
2	Gyroscope	CO1, CO 5	T2:2.1.5 R1:2.6
3	Static Force Analysis	CO 1,CO 4, CO 5, CO 6	T1:2.6 R3:3.6.5
4	Dynamic Force Analysis	CO 2, CO 6	T2:2.7 R2:2.18
5	Balancing	CO 2, CO 6	T2:2.22 R3:3.1.1

6	Journal Bearing	CO 2, CO 6	T1:2.5.1 T2:2.25
7	Universal Vibration	CO 3, CO 6	T2:2.26 R3:2.55
8	Whirling of Shaft	CO 3, CO 6	T2:2.3 R3:2.6
9	Mechanisms	CO 3, CO 6	T2:2.3 R1:2.6
10	Differential Gear Box	CO 4, CO 6	T1:2.6
11	Indexing	CO 4, CO 6	T2:2.7 R1:2.18

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design of flywheel for I.C engine and punch press.
2	Design of journal bearing using different lubrication oils and different speeds.
3	Design of ball bearing for different loads and estimation of life.
4	Design of differential gear box for automobile I.C Engine.
5	Design of inversion four bar mechanism.

Prepared by: **HOD,AE**
Dr Aravind Rajan Ayagara, Associate Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**AEROSPACE STRUCTURAL DYNAMICS**				
Course Code	AAEB25				
Program	B.Tech				
Semester	VII	AE			
Course Type	Core				
Regulation	IARE	R18			
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. Gooty Rohan, Assistant Professor				

I COURSE OVERVIEW:

The course aim is to teach basic concepts and recent developments related to mechanical vibrations, structural dynamics and vibration control. The course seeks to introduce students to the fundamentals of dynamics by providing an overview on mechanical vibration. Vibrations in machines and structures are typically undesirable as they produce stresses, energy losses and increased bearing loads. They contribute to structural wear and can lead to passenger discomfort in vehicles. This course covers the vibrations of discrete systems and continuous structures and introduces the computational dynamics of linear engineering systems. Learn how to derive equations of motion and design vibration isolation systems. Gain an understanding of the concepts of natural frequencies and mode shapes and their significance. Complete system modeling tasks and formulate equations to measure and ultimately minimize vibrations. The concepts of aero elasticity phenomena, effect of aero elasticity in flight vehicle design.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSB04	I	Waves and Optics
B.Tech	AAEB03	II	Engineering Mechanics
B.Tech	AAEB04	II	Mechanics of Solids

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Aerospace Structural Dynamics	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
0 %	Remember
44.4 %	Understand
33.3 %	Apply
22.2 %	Analyze
0 %	Evaluate
0 %	Create

VI COURSE OBJECTIVES:

The students will try to learn:

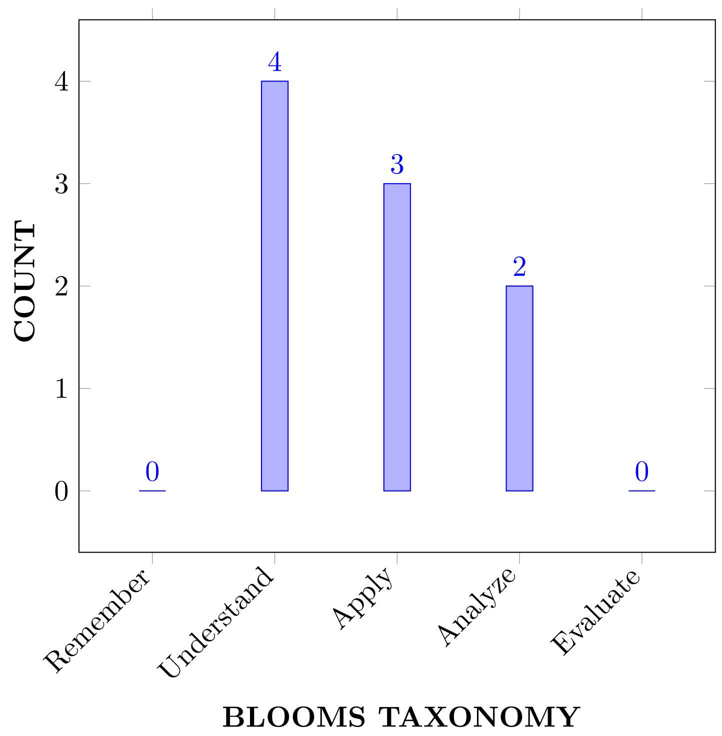
I	Demonstrate the knowledge of mathematics, science, and engineering by developing the equations of motion for vibratory systems and solving for the free and forced response.
II	Understand to identify, formulate and solve engineering problems. This will be accomplished by having students model, analyze and modify a vibratory structure order to achieve specified requirements.
III	Introduce to structural vibrations which may affect safety and reliability of engineering systems.
IV	Describe structural dynamic and steady and unsteady aerodynamics aspects of airframe and its components of space structures.

VII COURSE OUTCOMES:

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

CO 1	**Explain** the concepts of the equation of motion of free vibration and its response for determining the nature of single degree of freedom.	Understand
CO 2	**Demonstrate** the response of step function, periodic excitation (Fourier series and transform, Laplace transform) of Single DOF for determining the freely vibrating of a body.	Understand
CO 3	**Construct** the equation of motion of free vibration for the design of the analysis of the spring-mass system.	Apply
CO 4	**Apply** the various equations of forced vibration for determining the frequency of the body.	Apply
CO 5	**Understand** the torsional vibrations of rotor and geared systems for determining the DOF of the vibrating systems.	Understand
CO 6	**Develop** the formulation of stiffness and flexibility influence coefficients for simplifying solution of multi DOF systems.	Apply
CO 7	**Analyze** the transverse, longitudinal, torsional and lateral vibrations of cables, rods and beams for the design of continue elastic body.	Analyze
CO 8	**Understand** the difference between the static and dynamic aeroelasticity for determining the aeroelastic model of airfoils.	Understand
CO 9	**Analyze** the static and dynamic aeroelasticity of the typical airfoil and wing sections of aircraft using Eigen functions and Laplace equationfor design of aircraft wing.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3	CIE/Quiz/AAT
PO 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	Assignments
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	SEE/ CIE, AAT, QUIZ

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards	3	Quiz
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	2	Quiz
PSO 3	Make use of design, computational and experimental tools for research and innovation in aerospace technologies and allied streams, to become successful professionals, entrepreneurs and desire higher studies.	2	Quiz

3 = High; 2 = Medium; 1 = Low

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

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

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

COURSE OUTCOMES	PO'S PSO'S	**Justification for mapping (Students will be able to)**	No. of Key Competencies
CO 1	PO 1	Understand the concepts of the equation of motion of free vibration and its response for determining the nature of single degree of freedom using the knowledge of **mathematics, science and Engineering fundamentals.**	3
CO 2	PO 1	Recognize the principles of mathematics to build the governing equations for damped and undamped vibrations using the knowledge of **mathematics and science fundamentals.**	2
	PO 2	Formulate the response of step function, periodic excitation (Fourier series and transform, Laplace transform) of Single DOF for determining the freely vibrating of a body by using the **mathematics and the engineering knowledge.**	3
CO 3	PO 1	Determine the equation of motion of free vibration for the design of the analysis of the spring-mass system by applying the principles of **mathematics, science and engineering fundamentals.**	3
	PO 2	Apply the given **problem statement and formulate** the vibrating system by the provided **information and data** in reaching substantiated conclusions.	2
	PSO 1	Apply the equation of free vibrating system for the solving of the damped and damped system using **mathematics, science and Engineering fundamentals.**	1

CO 4	PO 1	Explain various equations of forced vibration for identifying the frequency of the vibrating system by applying the principles of **mathematics, science and engineering fundamentals.**	3
	PO 2	Understand the given **problem statement and formulate** variation of phase angle across different waves by the provided **information and data** in reaching substantiated conclusions by the interpretation of results.	2
	PSO 1	Apply the equation of forced vibration system for the solving of the damped and damped system using **mathematics, science and engineering fundamentals.**	1
CO 5	PO 1	Understand the torsional vibrations of rotor and geared systems for determining the DOF of the vibrating systems based on **mathematical principles and engineering fundamentals of** vibrations.	3
CO 6	PO 1	Develop the governing equations for a multi degree of freedom vibrating system by applying the principles of **mathematics, science and Engineering fundamentals.**	3
	PO 2	Applying the formula of stiffness and flexibility influence coefficients for simplifying solutions of multi DOF systems by using **mathematics and engineering knowledge.**	3
	PSO 1	Apply the equation of free vibrating system for the solving of the damped and damped system using **mathematics, science and Engineering fundamentals.**	1
CO 7	PO 1	Understand the concepts of the vibration for determining the frequency of cable, rod, shaft by using the knowledge of **mathematics, science and Engineering fundamentals.**	3
	PO 2	Apply the given **problem statement and formulate** transverse, longitudinal, torsional and lateral vibrations of cables, rods and beams information and data in reaching substantiated conclusions by the interpretation of results.	3
	PO 3	Analyse the results of the transverse, longitudinal, torsional and lateral vibrations for developing the new solution using appropriate **mathematics and engineering fundamentals.**	1
	PSO 1	Analyse the frequency of cable, shafts, beam for developing the new solutions on vibrating body using appropriate **mathematics, science and engineering fundamentals.**	1
	PSO 2	Simplify the equation of transverse, longitudinal, torsional and lateral vibrations for the solving of the damped and damped system using **mathematics, science and engineering fundamentals.**	1

CO 8	PO 1	Identify the difference between the static and dynamic aeroelasticity for determining the aeroelastic model of airfoils by using the **mathematics, science and engineering fundamentals.**	3
CO 9	PO 1	Understand the concepts of static and dynamic aeroelasticity for determining flutterness of the wing structure using the knowledge of **mathematics, science and Engineering fundamentals.**	3
	PO 2	Apply the given **problem statement and formulate** the equation of static and dynamic aeroelasticity for the solving of the vibrating system using **mathematics, science and engineering fundamentals.**	3
	PO 3	Analyse the equation of static and dynamic aeroelasticity for the solving of the damped and damped system using **mathematics and engineering fundamentals.**	1
	PSO 1	Analyse the various vibrations generated on aircraft for developing the new solutions using appropriate **mathematics, science and engineering fundamentals.**	1
	PSO 2	Simplify the equation of Rayleigh-Ritz method for the solving of the vibration on aircraft systems using **mathematics, science and engineering fundamentals.**	1

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

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

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

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	66.6	30	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	20	-	-	-	-	-	-	-	-	-	-	50	-	-
CO 4	100	20	-	-	-	-	-	-	-	-	-	-	50	-	-
CO 5	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	30	-	-	-	-	-	-	-	-	-	-	50	-	-
CO 7	100	30	10	-	-	-	-	-	-	-	-	-	50	50	-
CO 8	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 9	100	30	10	-	-	-	-	-	-	-	-	-	50	50	-

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	1	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 7	3	1	1	-	-	-	-	-	-	-	-	-	2	2	-
CO 8	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 9	3	1	1	-	-	-	-	-	-	-	-	-	2	2	-
TOTAL	27	6	2	-	-		-	-	-	-	-	-	10	4	-
AVERAGE	3	1	1	-	-		-	-	-	-	-	-	2	2	-

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1,PO 2	SEE Exams	PO 1,PO 2, PO 4	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	PO 9, PO 10	5 Minutes Video	PO 9, PO 10	Open Ended Experiments	-
Assignments	PO 1, PO 2, PO 3				

XVI ASSESSMENT METHODOLOGY INDIRECT:

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

XVII SYLLABUS:

MODULE I	**SINGLE-DEGREE-OF-FREEDOM LINEAR SYSTEMS**
	Introduction to theory of vibration, equation of motion, free vibration, response to harmonic excitation, response to an impulsive excitation, response to a step excitation, response to periodic excitation (Fourier series), response to a periodic excitation (Fourier transform), Laplace transform (Transfer Function).
MODULE II	**TWO-DEGREE-OF-FREEDOM SYSTEMS**
	Introduction, Equations of Motion for Forced Vibration, Free Vibration Analysis of an Undamped System, Torsional System, Coordinate Coupling and Principal Coordinates, Forced-Vibration Analysis, Semi definite Systems, Self-Excitation and Stability Analysis, Transfer- Function Approach, Solutions Using Laplace Transform, Solutions Using Frequency Transfer Functions.
MODULE III	**MULTI-DEGREE-OF-FREEDOM LINEAR SYSTEMS**
	Matrix formulation, stiffness and flexibility influence coefficients; Eigen value problem; normal modes and their properties; Free and forced vibration by Modal analysis; Method of matrix inversion; Torsional vibrations of multi-rotor systems and geared systems; Discrete- Time systems.
MODULE IV	**DYNAMICS OF CONTINUOUS ELASTIC BODIES**
	Introduction, transverse vibration of a string or cable, longitudinal vibration of a bar or rod, torsional vibration of shaft or rod, lateral vibration of beams, the Rayleigh-Ritz method.

MODULE V	**INTRODUCTION TO AEROELASTICITY**
	Static Aeroelasticity; Typical Section Model of an Airfoil: Typical Section Model with Control Surface, Typical Section Model—Nonlinear Effects. One Dimensional Aeroelastic Model of Airfoils: Beam-Rod Representation of Large Aspect Ratio Wing, Eigenvalue and Eigen function Approach, Galerkin‘s Method. **Dynamic Aeroelasticity;** Hamilton‘s Principle: Single Particle, Many Particles, Continuous Body, Potential Energy, Non potential Forces, Lagrange‘s Equations.

TEXTBOOKS

1. Bismarck-Nasr, M.N., —Structural Dynamics in Aeronautical Engineering‖, AIAA Education Series, 2 nd Edition, 1999.
2. Rao, S.S., —Mechanical Vibrations‖, Prentice-Hall, 5th Edition, 2011.
3. Earl H. Dowell, —A Modern Course in Aeroelasticity‖ Volume 217, Duke University, Durham, NC, USA.

REFERENCE BOOKS:

1. R.L. Bisplinghoff, H.Ashley, and R.L. Halfmann, —Aeroelasticity‖, Addison Wesley Publishing Co., Inc., 2nd Edition, 1996.
2. Leissa, A.W., Vibration of continuous system, The McGraw-Hill Company, 2nd Edition, 2011.
3. Inman, D.J., Vibration Engineering, Prentice Hall Int., Inc., 3rd Edition, 2001.

XVIII COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
1-2	Introduction to theory of vibration	CO 1	T2 : 1.2-1.13
3-5	Equation of motion, free vibration	CO 1	T1 : 2.1-2.2
6-7	Response to harmonic excitation, response to an impulsive excitation	CO 2	T1 : 2.3-2.4, T2:1.10.1
7-8	Response to a step excitation, response to periodic excitation (Fourier series)	CO 2	T1:1.11.1; T1:2.5-2.6
9-11	Response to a periodic excitation (Fourier transform), Laplace transform (Transfer Function).	CO 2	T1 : 2.7-2.8
12-13	Equations of motion, free vibration, the Eigenvalue problem, response to an external applied load	CO 3	T1:3.1-3.3
15	Damping effect; Modeling of continuous systems as multi degree of freedom systems, using Newton's second law to derive equations of motion	CO 3	T1:3.4; T2:6.2-6.3
15-16	Influence coefficients - stiffness influence coefficients, flexibility influence coefficients, inertia influence coefficients;	CO 3	T2: 6.4

17	Potential and kinetic energy expressions in matrix form, generalized coordinates and generalized forces	CO 4	T2:6.5-6.6
18-19	Lagrange‘s equations to derive equations of motion, equations of motion of undamped systems in matrix form, eigenvalue problem	CO 4	T2:6.7-6.9
20-22	Solution of the Eigenvalue problem, expansion theorem, unrestrained systems, free vibration of undamped systems	CO 5	T2:6.10-6.13
23-25	Forced vibration of undamped systems using modal analysis, forced vibration of viscously damped systems	CO 5	T2:6.14-6.15
26-29	Introduction to nonlinear vibrations, simple examples of nonlinear systems, physical properties of nonlinear systems	CO 6	T1:5.1-5.3 T3:3.3
30-31	solutions of the equation of motion of a single-degree-of-freedom nonlinear system, multi-degree-of-freedom nonlinear systems	CO 6	T1:5.4-5.5
32-34	Introduction to random vibrations; classification of random processes, probability distribution and density functions, description of the mean values in terms of the probability density function	CO 6	T1:6.1-6.4 R3:4.4
35-36	Properties of the autocorrelation function, power spectral density function, properties of the power spectral density function, white noise and narrow and large bandwidth, single-degree-of-freedom response, response to a white noise	CO 7	T1:6.5-6.10 R3:5.4 T3:4.3
37-38	Introduction, transverse vibration of a string or cable	CO 7	T2:8.1-8.2
39-41	longitudinal vibration of a bar or rod	CO 7	T2:8.3
42-44	torsional vibration of a bar or rod	CO 7	T2:8.4 R2:5.3
45-46	Lateral vibration of beams, the Rayleigh-Ritz method.	CO 7	T2:8.5-8.7
47-48	Collar’s aero elastic triangle, static aeroelasticity phenomena	CO 8	R1:1.2
49-51	Dynamic aero elasticity phenomena, aero elastic problems at transonic speeds	CO 8	R1:2.2
51-53	Aero elastic tailoring, active flutter suppression	CO 9	T1:7.1-7.3 R2:1.3
54-55	Effect of aero elasticity in flight vehicle design	CO 9	R1:3.4

Signature of Course Coordinator **HOD,AE**
Mr. Gooty Rohan Assistant Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**FLIGHT VEHICLE DESIGN LABORATORY**				
Course Code	AAEB26				
Program	B.Tech				
Semester	VII				
Course Type	Laboratory				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Ms.K Sai Priyanka, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB26	VII	FLIGHT VEHICLE DESIGN LABORATORY

II COURSE OVERVIEW:

The aim of Flight Vehicle design (FVD) LAB is to introduce students the overview of the design process. The course covers basic principles of conceptual design process of an aircraft and the related details of all design techniques. After completion of the course the student gains adequate knowledge to design all the different phase of an aircraft design. Weight estimation for different aircrafts

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	Understand the basic skills involved in weight estimation for aircraft conceptual design process. .
II	Illustrate relevant theoretical knowledge, applicable for initial sizing and configuration layout of aircraft.
III	Evaluate basic techniques for design of aircraft using given design requirement and mission profiles.

VII COURSE OUTCOMES:

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

CO 1	**Choose** data collection for conceptual sketch from existing aircraft for understanding aerodynamic performance requirements.	Apply
CO 2	**Classify** rubber engine sizing of a given fighter aircraft for calculating the take -off weights in order so that the aircraft meets all set requirements	Analyze
CO 3	**Make** use of airfoil geometry and co-ordinates for obtaining the required 3D model by using designer tools like catiaV5.	Apply
CO 4	**Simplify** the performance estimations involving design layout for calculating the variation of C L and CD at angle of attack.	Analyze
CO 5	**Estimate** take-off gross weight of simple cruise mission profile for calculating the empty weight fraction.	Evaluate
CO 6	**Identify** the total drags on an aircraft and calculate the total weight, thrust and drag for exit pressure and Mach number for the given nozzle configurations	Apply

VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIA
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Utilize the concept of calibration to a considerable extent appreciate (understanding) their importance and applicability (apply) in solving (complex) fluid flow engineering problems by applying the **principles of Mathematics and Engineering**	3
	PO 2	Understand the (given **problem statement**) calibration procedure for (provided **information and data**) in reaching substantiated conclusions by the interpretation of results	3
	PSO 3	Apply (**knowledge**) properties, various types and patterns of fluid flow configurations (apply) for solving design problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 2	PO 1	Explain (understanding) various effects of viscosity in flow through pipes and apply Newtons law of viscosity, in calculating energy loss by applying **principles of Mathematics, Science and Engineering**	3
	PO 5	Understand the (given **problem statement**) effects of viscosity, and capillary rise for the bodies immersed in fluids. (from the provided **information**) in solving analysis problems.	2
	PSO 3	Apply (**knowledge**) Newtons law of viscosity (understanding) in body, under different inlet conditions in (apply) solving flow through pipes by applying the principles of **Mathematics, Science and Engineering**	3
CO 3	PO 1	Summarize (**knowledge**) the concept of pressure measuring devices applications and effect of buoyancy on submerged bodies (understanding) their importance and applicability (apply) in solving (complex) fluid flow engineering problems by applying the textbfprinciples of Mathematics, Science and Engineering	3
	PO 3	Understand the given **problem statement** and formulate (complex) of pressure measuring devices applications and effect of buoyancy on submerged bodies (understanding) their importance and applicability (apply) in solving (**complex**) fluid flow engineering problems from the provided information and substantiate with the **interpretation** of variations in the **results**.	3
	PSO 3	Apply (knowledge) various effects of viscosity, static pressure, surface tension, Newton's law of viscosity, pressure difference and capillary rise (apply) in solving aircraft analysis problems by applying the **principles of Mathematics, Science and Engineering**	3

CO 4	PO 1	Recognize (knowledge) the importance and application (apply) of dimensions, units and dimensional homogeneity in solving (complex) engineering problems with specific emphasis to fluid mechanics by applying the **principles of Mathematics, Science and Engineering**	3
	PO 5	Understand the given **problem statement and formulate** the dimensional analysis and similarity parameters for predicting physical parameters that govern fluid systems in designing prototypes devices	2
	PSO 3	Apply (knowledge) concept of dimensional analysis and similarity parameters for predicting physical parameters (understanding) for the fluid flow analysis used in designing prototypes devices (apply) solving design problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 5	PO 1	Apply the basic conservation laws of science for various phenomena of fluid systems and use **mathematical principles** for deriving (complex) fluid flow engineering equations by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals** of fluid mechanics.	3
	PO 3	Understand the given **problem statement** and formulate (complex) fluid flow engineering phenomena and system for deriving various governing equations of fluid mechanics from the provided information and substantiate with the **interpretation** of variations in the results.	2
	PO 5	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of fluid mechanics.	2
	PSO 3	Apply (knowledge) concept of dimensional analysis and similarity parameters for predicting physical parameters (understanding) for the fluid flow analysis used in designing prototypes devices (apply) solving design problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 6	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** principles to understand the Bernoulli Equation for real flows and its applications	2
	PO 3	Using Euler equation of motion derive the Bernoulli equation to analyze complex fluid flow problems using **principles of mathematics and engineering sciences.**	3

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

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

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

XIII ASSESSMENT METHODOLOGY DIRECT:

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

XIV ASSESSMENT METHODOLOGY INDIRECT:

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

XV SYLLABUS:

WEEK I	**OBJECTIVES AND REQUIREMENTS OF THE VEHICLE**
	Data collection for conceptual sketch from existing aircraft includes Mission Payload Aerodynamic and performance requirements.
WEEK II	**CONCEPTUAL SKETCH AND WEIGHT ESTIMATION**
	Conceptual sketch of candidate aircraft (3-view). b. First estimation of gross take-off weight with trade-off studies
WEEK III	**AIRFOIL DESIGN AND CONSTRAINT ANALYSIS**
	Airfoil and wing geometry selection
WEEK IV	**CONSTRAINT ANALYSIST**
	Determination of Thrust-to-Weight ratio and Wing Loading
WEEK V	**INITIAL SIZING-I**
	Rubber engine and fixed engine sizing.
WEEK VI	**INITIAL SIZING-II**
	Configuration layout, crew station, passengers and payload.
WEEK VII	**PERFORMANCE ESTIMATIONS**
	Performance constraint analysis
WEEK VIII	**LOAD ESTIMATIONS-I**
	Landing gear loads
WEEK IX	**LOAD ESTIMATIONS-II**
	Propulsion system load.
WEEK X	**COST ESTIMATION**
	a. Cost estimation and parametric analysis b.Optimization and trade studies
WEEK XI	**DESIGN CASE STUDY-I**

	a. Design study of DC-3 and B-747
WEEK XII	**DESIGN CASE STUDY-II**
	a. Design study of F-16 and SR-71

TEXTBOOKS

1. Daniel P. Raymer —Aircraft design a conceptual approach‖, 5th Edition 1999

REFERENCE BOOKS:

1. Daniel P. Raymer —Conceptual flight Vehicle design‖, 4th Edition 1998

XVI COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Determine the Data collection for conceptual sketch from existing aircraft includes Mission and Payload Aerodynamic and performance requirements.	CO 1	R1: 1
2	Determine the Conceptual sketch of candidate aircraft first estimation of gross take-off weight with trade-off studies.	CO 2	R2: 3.5
3	Determine the Airfoil and wing geometry selection	CO 2	R1: 3.4
4	Determination of Thrust-to-Weight ratio and Wing Loading	CO 3	R1: 2.2
5	Determine the Rubber engine and fixed engine sizing.	CO 3	R1: 2.4
6	Determine the Configuration layout, crew station, passengers and payload.	CO 4	R3: 4.5
7	Determine the Performance constraint analysis.	CO 4	R3: 4.6
8	Determine the Load estimations of Landing gear.	CO 5	R2: 5.1
9	Determine the Propulsion system load.	CO 5	R2: 5.2
10	Determine the Cost estimation and parametric analysis and optimization and trade studies	CO 6	R1: 7.1
11	Determine the design study of DC-3 and design study B-747	CO 6	R1:7.2
12	Determine the dynamics of F-16 and dynamics of SR-71	CO 6	R1:7.3

XVII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Requirements of new design:** Demonstration a design which includes type of mission payload and aerodynamic and performance requirements.
2	**Weight Calculations:** Demonstration of rubber engine sizing of a given fighter aircraft requirements.
3	**Constraint analysis:** Generating airfoil coordinates of a given airfoil series and generate airfoil geometry.

4	**Initial sizing-I** the total drags on an aircraft and calculate the total weight, thrust and drag from the given .
5	**Performance and load estimations:** Encourage students to new design wing according to the given data

Signature of Course Coordinator **HOD,AE**
Ms.K Sai Priyanka, Assistant Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**AUTOMATIC CONTROL OF AIRCRAFT**				
Course Code	AAEB49				
Program	B.Tech				
Semester	VII	AE			
Course Type	PE				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr.Yagya Dutta Dwivedi, Professor				

I COURSE OVERVIEW:
This course is intended to study the automatic control of the flight vehicles through the air or in outer space. It concerns the forces and moments, that are acting on the air- vehicles to determine the position and attitude with respect to the time. It also develops as an engineering science throughout succeeding generations of aeronautical engineers to support increasing demands of autonomous aircraft navigation and control. It has a major role to play in the design of modern aircraft to ensure efficient, comfortable and safe flight. Modern aircraft control is ensured through automatic control systems known as autopilot in association with Fly-by- Wire, to increase safety, facilitate the pilot's task easier and improve flight qualities.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB09	IV	Flight Mechanics
B.Tech	AAEB13	V	Aircraft stability and control

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Automatic control of aircraft	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1.

Percentage of Cognitive Level	Blooms Taxonomy Level
25 %	Understand
60 %	Apply
15 %	Analyze

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 2), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (Table 3).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams

Quiz - Online Examination

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Open Ended Experiment
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

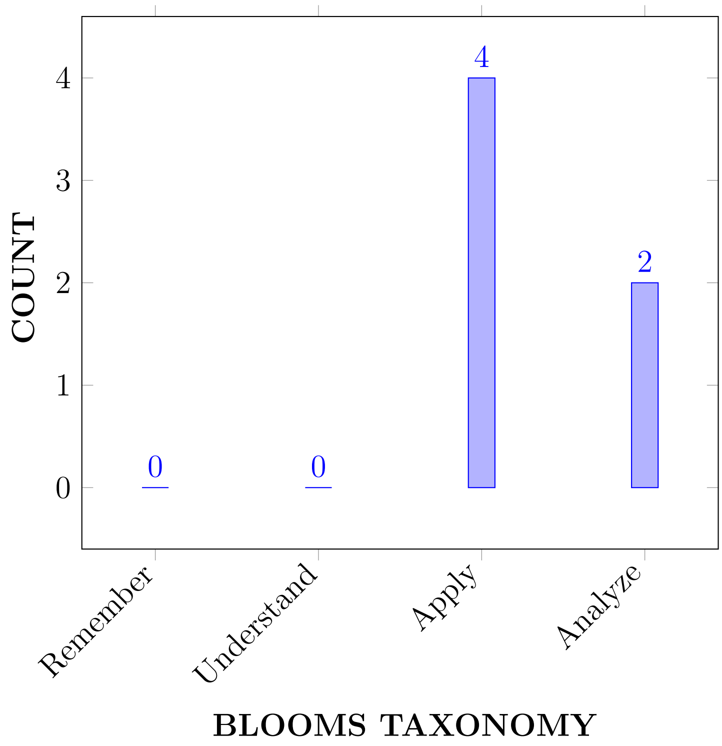
I	The fundamental theory of guidance and control systems of aircraft and also different augmentation systems used for aircraft and space vehicles.
II	Various components and propellants of a chemical rocket propulsion system with its characteristics and applications.Different autopilot systems, flight path stabilization and Automatic Flare Control systems used for flight vehicles.
III	The operating principle of guided missile, and the guidance, control and instrumentation needed to acquire theThe modern automatic control systems like Fly-by-Wire, Fly-by-Optics systems and different flight control laws design using different algorithms.
IV	Advanced computational tools to design of navigation and guidance systems for automation of aircrafts, missiles, helicopters and space launch vehicles.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Identify** the principles of guidance, navigation, and governing laws for the control of aircraft for getting the desired aircraft attitude.	Apply
CO 2	**Demonstrate** the automatic flight control system under different types of flight conditions for assessing the stability and control of an airplane	Apply
CO 3	**Examine** the automatic gain schedule concept for airplane control by plotting the required curve f or obtaining desired automatic control of the flight vehicle.	Analyze
CO 4	**Apply** the concept of displacement autopilots and orientation control in longitudinal motion with its elements f or optimal flight automated control of the airplane.	Apply
CO 5	**Make use of** the aircraft longitudinal flight control laws by using simple stepping algorithm for optimizing the required control of the flight vehicles.	Apply
CO 6	**Analyze** the fly-by-wire flight control by using flight control laws and modern computational tools system for the assessment of redundancy and failure of the aircraft operation.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	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	Assignments/ SEE /CIE, AAT, QUIZ

PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Assignments
PO 9	**Individual and Teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Class group / Multi-disciplinary group
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	Discussion on Innovations / Presentation
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	SEE/ CIE, AAT, QUIZ

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	2	Research papers / Group discussion / Short term courses
PSO 3	Make use of design, computational and experimental tools for research and innovation in aerospace technologies and allied streams, to become successful professional, entrepreneurs and desire higher studies.	2	Research papers / Industry exposure

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	**PROGRAM OUTCOMES**												**PSO'S**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	
CO 3	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	-	-	-	-	-	-	-	-		-	✓	-
CO 5	✓	-	-	✓	-	-	-	-	-	-	-	-	-	✓	-
CO 6	✓	✓	-	-	-	-	-	-	-	-	-		-	-	✓

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	**Recollect (knowledge)** the basic concept of static stability and to an extent appreciate (understand) the importance of longitudinal, lateral and directional modes of stability by applying the principles of mathematics and science.	3
CO 2	PO 1	**Describe (knowledge)** the state of equilibrium, control and trim inputs required (understanding) for an aircraft in longitudinal control using principles of mathematics, science, and engineering fundamentals.	3
	PO 2	Recognize problems related to design of civil and military aircraft stability and control characteristics in longitudinal/ lateral direction by **using first principles of mathematics and engineering sciences.**	5
CO 3	PO 1	**Recognizing (knowledge)** the contribution of aircraft components which affects static stability and control of airplane.**by using scientific principles and methodology.** (application) .	3
	PO 2	Recognize problems related to design of civil and military aircraft stability and control characteristics in longitudinal/ lateral direction by **using first principles of mathematics and engineering sciences.**	6
	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, related to the automatic control of aircraft with control auto stabilization**.	5
CO 4	PO 1	Identify (knowledge) the lateral autopilot and its elements to control with the **fundamentals of mathematics, science, and engineering fundamentals**.	2
	PO 2	Apply (knowledge) the appropriate lateral autopilot mechanism to reach substantiated conclusions (application) using **first principles of mathematics and engineering sciences.**	7
	PSO 2	Make use of design, computational and experimental tools for research and innovation in aerospace technologies and allied streams, to become **successful professional, entrepreneurs and desire higher studies**.	2
CO 5	PO 1	Interpret the specific coupling between lateral and directional control with the **knowledge of mathematics, science and engineering fundamentals related to aeronautics.**	2

	PO 4	**Conduct Investigations of Complex Problems** Use research-based knowledge and research methods including **design of experiments, analysis and interpretation of data, and synthesis of the information, to provide valid conclusions, related to the automatic control of aircraft with control auto stabilization**.	5
	PSO 2	Make use of design, computational and experimental tools for research and innovation in aerospace technologies and allied streams, to become **successful professional, entrepreneurs and desire higher studies**.	2
CO 6	PO 1	Construct the mathematical model of of aircraft motion in longitudinal control by Knowledge and understanding of complex engineering problem using mathematical principles **using fundamentals of science &and engineering fundamentals.**	3
	PO 2	Derive the mathematical model of aircraft motion in lateral and directional cases of control for establishing the stability of the flight vehicles using **complex engineering problems.**	5
	PSO 3	Understand the characteristics of aircraft longitudinal / lateral control by using modern tool to go further one level to become **entrepreneur**.	1

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	Program Outcomes/ No. of Key Competencies Matched												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	6	-	5	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	7	-	-	-	-	-	-	-	-	-		-	2	-
CO 5	2	-	-	5	-	-	-	-	-	-	-	-	-	2	-
CO 6	3	5	-	-	-	-	-	-	-	-	-		-	-	1

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	100	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	60	-	50	-	-	-	-	-	-	-	-	-	-	-
CO 4	67	70	-	-	-	-	-	-	-	-	-		-	67	-
CO 5	67	-	-	50	-	-	-	-	-	-	-	-	-	67	-
CO 6	100	50	-	-	-	-	-	-	-	-	-		-	-	34

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
2 - $40\% < C < 60\%$ –Moderate
1-5 $< C \leq 40\%$ – Low/ Slight
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	**PROGRAM OUTCOMES**												**PSO'S**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	3	-	-	-	-	-	-	-	-	-		-	3	-
CO 5	3	-	-	2	-	-	-	-	-	-	-	-	-	3	-
CO 6	3	2	-	-	-	-	-	-	-	-	-		-	-	1
TOTAL	18	9	-	4	-	-	-	-	-	-	-	-	-	6	1
AVERAGE	3	2.2	-	2	-	-	-	-	-	-	-	-	-	3	1

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	Concept Video	✓	Open Ended Experiments	✓
Assignments	-	Techtalk	✓		

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVII SYLLABUS:

MODULE I	**INTRODUCTION**
	Introduction to Guidance and control: Definition, historical background.
MODULE II	**AUGMENTATION SYSTEMS**
	Need for automatic flight control systems, stability augmentation systems, control augmentation systems, gain scheduling concepts.

MODULE III	**LONGITUDINAL AUTOPILOT**
	Displacement Autopilot: Pitch orientation control system, acceleration control system, glide slope coupler and automatic flare control. Flight path stabilization, longitudinal control law design using back stepping algorithm.
MODULE IV	**LATERAL AUTOPILOT**
	Damping of the Dutch roll, methods of obtaining coordination, yaw orientation control system, turn compensation, automatic lateral beam guidance.
MODULE V	**FLY BY WIRE FLIGHT CONTROL**
	Introduction to Fly-by-wire flight control systems, fly-by-wire flight control features and advantages, control laws, redundancy and failure survival, digital implementation, fly-by-light flight control.

TEXTBOOKS

1. Blake Lock, J.H, —Automatic control of Aircraft and missiles, John Wiley Sons, New York, 1990.

2. Stevens B.L and Lewis F.L, —Aircraft control and simulation, John Wiley Sons, New York, 1992

3. Collinson R.P.G, —Introduction to Avionics, Chapman and Hall, 1st Edition India, 1996.

REFERENCE BOOKS:

1. Garnel.P. and East. D.J, —Guided Weapon control systems, Pergamon Press, Oxford, 1st Edition 1977

2. Bernad Etikin, —Dynamic of flight stability and control, John Wiley, 1st Edition 1972.

3. Nelson R.C, —Flight stability and Automatic Control, McGraw Hill, 1st Edition 1989.

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Discussion on Outcome Based Education		
DISCUSSION OF QUESTION BANK			
2	Basic introduction to guidance and control.	CO 1	T2: 1.1-1.5, T1: 4.1
3	Definition of different types of guidance and the terms used	CO 1	T2: 2.1-2.2, R1: 3.1
4	Historical background	CO 1	T2: 2.1-2.2, R1: 3.1
5	Development of the guidance system	CO 1	R4: 2.8
6	Types of guidance system- Active verses passive homing guidance	CO 1	T2: 2.3-2.4
7-8	Command guidance system	CO 2	R4: 2.7.1
8	Need for automatic flight control systems	CO 1	R4: 2.7.1

9	Stability augmentation systems	CO 1	T2: 3.4
10	Control augmentation systems	CO 1	T2: 3.4
11	Gain scheduling concepts	CO 1	T2: 3.3
12	Longitudinal Control and Revision	CO 1	T4: 7.1
13	Displacement Autopilot	CO 1	R4: 6.3.3
14	CL trim Vs δ_e Trim and Numerical	CO 1	R4: T6.3.2
15	Pitch orientation control system	CO 2	R4: T6.3.2
16	Trim: Maneuver	CO 2	R4: T6.3.2
17	Maneuver Point- Stick Fixed	CO 2	T1 5.5
18	Acceleration control system	CO 2	R4: 7.1
19	Directional Stability and Control	CO 2	T2: 5.1
20	Lateral Stability and control	CO 2	T2: 5.2
21	Glide slope coupler and automatic flare control	CO 2	R4: 4.2.1
22	Hinge moment and hinge derivative	CO 2	R4: 4.2.2
23	Flight path stabilization	CO 2	T1: 5.2
24	Longitudinal control law design using	CO 2	T2: 6.3-6.4
25	Back stepping algorithm	CO 3	T2: 5.2
26	Damping of the Dutch roll, Dutch roll basic concepts	CO 3	T2: 5.2
27	Methods of obtaining coordination	CO 3	T2: 5.2
28	Longitudinal control auto-pilot	CO 3	T2: 13.1-13.2
29	Yaw orientation control system	CO 4	T2: 13.1-13.2.5
30	Euler's Angle	CO 4	T2: 13.2.6
30	Turn compensation	CO 5	T2: 13.2.7
31	Automatic lateral beam guidance	CO 5	T4: 11.1-11.2
32	Introduction to Fly-by-wire flight control systems	CO 5	T4: 11.2-11.4
33	Fly-by-wire flight control features and advantages	CO 5	T1:11.1, T4:14.1
34	Control Laws	CO 5	T1:11.1, T4:14.4
35	Primary control laws, Normal laws	CO 5	T1:11.2-11.4, T4:14.3
36	Alternate laws, Direct laws	CO 5	R4:15.3.1
37	Redundancy and failure survival m	CO 6	T1:11.1, T4:14.3-14.4
38	Digital implementation	CO 6	R4:15.4
39	Fly-by-light flight control of airplane	CO 6	R4:15.3.1
40	Fly by Optics control of airplane	CO 6	T4:14.3-14.4
PROBLEM SOLVING/ CASE STUDIES			
1	Historical development of navigational systems- a review.	CO 1	T2: 1.1-1.5, T1: 4.1
2	A case study of stability augmentation system	CO 1	T2: 3.4
3	Guidance systems and its technical development for use in Write Brothers to modern aircraft	CO 1	R4: 2.8
4	Development of Flight augmentation system- a review	CO 2	R4: T6.3.2

5	Numerical problems related to guidance system	CO 2	R4: T6.3.2
6	CL Basic gain scheduling system and its application and modern development in this area.	CO 2	R4: T6.3.2
7	Determination of Neutral point and maneuvering point	CO 3	R4:5.2
8	The development of longitudinal autopilot used for aircraft- a case study.	CO 4	T2:5.2
9	Methods to control the aircraft pitch by autopilot- a historical snapshot.	CO 4	T2: 5.2
10	Discussion on the dynamic stability with damping and dutch roll modes	CO 5	T2: 13.1-13.2.5
11	Problems of Dynamic Stability and revision	CO 5	T4: 11.2-11.4
12	Yaw orientation control by lateral autopilot	CO 5	T2: 13.2.6
13	Fly bt Wire and its development with historical progress a report.	CO 6	T4:14.3-14.4
14	Problems of control law related to automatic control of aircraft.	CO 6	T4:14.3-14.4
15	Solving Control problems by finding roots and determination of dynamic stability and performance	CO 6	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Longitudinal static stability , criteria, Effect of components on static stability	CO 1	T2: 1.1-1.5
2	Lateral and directional stability, effect of vertical tail, criteria, Finless aircraft	CO 2	T4:7.3
3	Aircraft axis system, Forces and moments, 6-DOF, Moment of inertia, Eulers angle	CO 3, 4	R4:5.1, T2: 6.3-6.4
4	Velocity derivative, AOA derivative, Mach tuck derivative, Perturbation theory,	CO 5	T1:7.5
5	Dynamic stability, Dynamic modes, natural frequency, Damping ratio, Longitudinal modes, Lateral and direction dynamic modes	CO 6	T1: 12.1
DISCUSSION OF QUESTION BANK			
1	Guidance and control of the airplane.	CO 1	T2: 1.1-1.5
2	Aircraft fligjt control augmentation system.	CO 2	R4: T6.3.2
3	Longitudinal Autopilot.	CO 3, 4	R4:5.1
4	Lateral Autopilot	CO 5	T4: 11.2-11.4
5	Fly by Wire in airplane	CO 6	T1:11.2-11.4, T4:14.3

Signature of Course Coordinator **HOD,AE**
Dr. Yagya Dutta Dwivedi, Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**FLIGHT VEHICLE DESIGN**				
Course Code	AAEB24				
Program	B.Tech				
Semester	VII	AE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms K. Sai Priyanka, Assistant Professor				

I COURSE OVERVIEW:

This course is designed to provide students an understanding of procedure followed in conceptual design of an aircraft, meeting the user-specified design requirements and safety considerations specified by the aircraft certification agencies. The course introduces theoretical basics of methods and models that are used in the conceptual airplane design and discusses the theoretical problem-solving skills related to analysis and design of flight vehicle structures. This course explains re-sizing and of a baseline civil transport aircraft to meet a specified market requirement.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB09	IV	Flight Mechanics
B.Tech	AAEB10	IV	Aerodynamics
B.Tech	AAEB14	IV	Analysis of Aircraft Structures

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Flight Vehicle Design	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
✓	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
50 %	Understand
25 %	Apply
15 %	Analyze
0 %	Evaluate
0 %	Create

VI COURSE OBJECTIVES:

The students will try to learn:

I	The fundamental concepts of various aerofoil characteristics and blend the best suitable requirements for various applications designing in various applications.
II	Initial sizing of fuselage and tail plane design; static stability; structural loading; cost analysis; takeoff and landing; and specification of (T/W) ratio and wing loading (W/S).
III	The characteristics of stability and performance of an aircraft and the role of primary and secondary controls in longitudinal and lateral stability.
IV	The Conceptual designs of aerospace vehicles, components, missions, or systems that incorporate realistic constraints/applicable engineering standards.

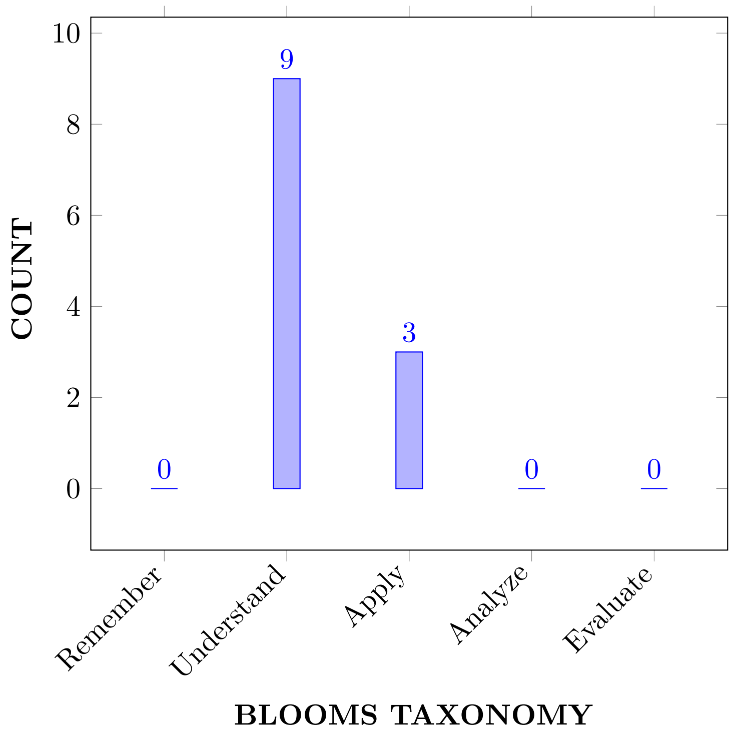
VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Understand** the concept of phases of aircraft design and the importance of conceptual design process involved in the aerodynamic design of an airplane.	Understand
CO 2	**Describe** the concept of airfoil selection, design and airfoil design considerations for wing and tail geometry.	Understand
CO 3	**Explain** geometrical sizing of fuselage, wing, tail, control surfaces, and development of configuration lay out for conceptual sketch.	Understand

CO 4	**Explain** the effects of camber, angle of attack and thickness on the aerodynamic characteristics of an airfoil.	Understand
CO 5	**Solve** the performance parameters of an aircraft takeoff stage to landing based on the aerodynamic forces and moments acting on the body.	Understand
CO 6	**Explain** the different types of Pyrotechnics and their usage in real world applications by understand its limitations and safety measures.	Apply
CO 7	**Classify** the types of landing gears and sub systems arrangements, guidelines and significance of design layout for the report of initial specifications.	Apply
CO 8	**Explain** jet and propeller driven airplane performance for (takeoff/landing distance, range, endurance, climb, maneuver).	Apply
CO 9	**Understand** selection criteria and properties of materials to perform under adverse conditionsfor design the new components as per the requirements.	Understand
CO 10	**Understand** Elements of life cycle cost parametric analysis, optimization, refined sizing trade studies and its estimating methods for airline economics.	Understand
CO 11	**Discuss** the importance of the aircraft wing, for generating maximum lift by reducing the specific fuel consumption.	Understand
CO 12	**Explain** different material properties and their usage in different segments of aircraft and spacecraft.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	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	Assignments/ SEE /CIE, AAT, QUIZ
PO 5	Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Assignments
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	SEE/ CIE, AAT, QUIZ

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards	3	Quiz
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	1	Quiz

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	-	✓	-	-	-	-	-	-	-	-	-	-
CO 5	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	✓	-	-	-	-	-	-	-	-		-	-	-
CO 7	✓	-	-	-	-	-	-	-	-	-	-	-	✓		-
CO 8	✓	-	-	-	-	-	-	-	-	-	-	-	-	✓	-
CO 9	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 10	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 11	✓	✓	-	-	-	-	-	-	-	-	-	-	-		-
CO 12	-	✓	-	-	✓		-	-	-	-	-	✓	-	-	-

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply **the knowledge of Mathematics, Sciences and Engineering fundamentals principles** to of conceptual design process and phases involved in the aero-dynamic design process of an airplane.	3
	PO 2	Identify **the problem statement** (mission requirement), select the appropriate aircraft required for carrying the payload by reviewing the literature **(information and data collection)** suitable to mission requirement.	2
CO 2	PO 1	Apply **the knowledge of Mathematics, Sciences and Engineering fundamentals principles** for concept of airfoil selection and various series of airfoils.	3
	PO 2	Analyze the performance parameters and various aerodynamic forces acting on the for an aircraft and spacecraft using the first **principles of Mathematics and engineering sciences.**	2
	PO 4	Understanding of **Engineering principles** such as hydrostatic forces and Archimedes principle to **apply them to analyze key engineering process** like behavior of pressure distribution in liquids.	4
CO 3	PO 1	Identify the role of different parts of an aircraft using **principles of mathematics, science, and engineering fundamentals.**	3
CO 4	PO 1	Illustrate the effect of camber angle w.r.t forces and moments acting on aircraft by **applying the knowledge of Mathematics, Sciences and Engineering fundamentals principles.**	3

	PO 2	Determine the performance parameters for an aircraft **using first principles and Mathematics and Engineering sciences.**	2
	PO 5	Illustrate CL vs CD graph for an aircraft and flying at different flight conditions using **modern Engineering and IT tools (MATLAB/Excel to solve complex engineering problems.**	1
CO 5	PO 1	Analyze different Engine cycles used for the propulsion system of an aircraft and spacecraft **using fundamentals of science and engineering fundamentals.**	2
CO 6	PO 1	Analyze differentlift curve slope, maximum lift coefficient, complete drag builds up **using fundamentals of science and engineering fundamentals.**	3
	PO 2	Categorize the sub system arrangements concept of based on its physical state and its usage in **complex engineering problems.**	3
	PO 3	Investigate and define a problem and identify constraints mission profile including **environmental and sustainability limitations, and safety and risk assessment issues** when dealing with manufacturing of different components of aircraft and spacecraft.	2
CO 7	PO 1	Understand different types of landing gears arrangements for guidelines by **applying the knowledge of sciences and Engineering fundamentals principles**	3
CO 8	PO 1	Describe **(knowledge** different control derivatives for static and lateral directional stability using **principles of mathematics, natural science, and engineering fundamentals.**	3
	PSO 2	Extending the focus to understand **the innovative and dynamic challenges**involve the guidance system of an aircraft.	1
CO 9	PO 1	Evaluate the performance characteristics of aircraft dynamic analysis using the basic understanding of **engineering science and mathematical equations**	3
	PO 2	Identify**the problem statement** (mission requirement), select appropriate materials and the propulsive systems required for flying an aircraft into different altitudes by reviewing the literature **(information and data collection)**suitable to mission requirement..	2
CO 10	PO 1	Apply the **knowledge of engineering fundamentals** to estimate the methods of aircraft and airline economics for life cycle cost	1
CO 11	PO 1	Apply the knowledge of **Sciences and Engineering fundamentals** for design and development for aircraft and installed engine propulsion systems.	2

	PO 2	Identify the proper cooling system for a different propeller engine system (complex system) using the first principle of natural **sciences and Engineering sciences.** fluid flow problems in real world applications by **application of Modern tools.**	1
CO 12	PO 1	Apply **the knowledge of sciences and Engineering fundamentals principles**to design a prototype of different aircraft and spacecraft components.	2
	PO 5	Make use of **computational/ Experimental tools** to synthesize and analyze aerodynamics of aircraft by application of Modern tools.	1

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	Program Outcomes/ No. of Key Competencies Matched												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	2	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-	1	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 7	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 8	3	-	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 9	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 10	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 11	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 12	3	-	-	-	1	-	-	-	-	-	-	5	-	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.7	30	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	30	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	30	-	-	20	-	-	-	-	-	-		-	-	-
CO 5	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	40	20	-	-	-	-	-	-	-	-		-	-	-

CO 7	100	-	-	-	-	-	-	-	-	-	-	-	66.6	-	-
CO 8	100	-	-	-	-	-	-	-	-	-	-	-	-	100	-
CO 9	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 10	100	30	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 11	100	30	-	-	-	-	-	-	-	-	-	-	-		-
CO 12	100	-	-	-	20	-	-	-	-	-	-	100	-		-

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - 0≤ C≤ 5% – No correlation

2 - 40 % <C < 60% –Moderate

1-5 <C≤ 40% – Low/ Slight

3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	1	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	-	3	-	-	-	-	-	-		-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	1	2	-	-	-	-	-	-	-	-		-	-	-
CO 7	3	-	-	-	-	-	-	-	-	-	-	-	3		-
CO 8	3	-	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 9	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 10	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 11	3	1	-	-	-	-	-	-	-	-	-	-	-		-
CO 12	3	-	-	-	3		-	-	-	-	-	2	3	3	-
TOTAL	36	6	-	-	6		-	-	-	-	-	2	3	3	-
AVERAGE	3	1	-	-	3		-	-	-	-	-	1	1	1	-

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1,PO 2, PO3,PSO 1, PSO 2	SEE Exams	PO 1,PO 2, PO3,PSO 1, PSO 2	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 4	Tech talk	PO 4
Assignments	PO 3,PSO 1, PSO 2				

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVII SYLLABUS:

MODULE I	**OVERVIEW OF THE DESIGN PROCESS**
	Phases of aircraft design, aircraft conceptual design process, project brief / request for proposal, problem definition, information retrieval, integrated product development and aircraft design. initial conceptual sketches, takeoff gross weight estimation, airfoil selection, airfoil design, airfoil design considerations, wing geometry and wing vertical location, wing tip shapes, tail geometry and arrangements, thrust to weight ratio, thrust matching, wing loading performance, constraint analysis.
MODULE II	**INITIAL SIZING AND CONFIGURATION LAYOUT**
	Sizing with fixed engine and with rubber engine. geometry sizing of fuselage, wing, tail, control surfaces, development of configuration lay out from conceptual sketch. the inboard profile drawing, lofting definition, significance and methods, flat wrap lofting, special consideration in configuration lay out, Isobar tailoring, Sears-Haack volume distribution, structural load paths, radar, IR, visual detectability, aural signature, considerations of vulnerability, crashworthiness, producibility, maintainability, fuselage design, crew station, passengers and payload.

MODULE III	**PROPULSION, FUEL SYSTEM INTEGRATION, LANDING GEAR AND BASELINE DESIGN ANALYSIS - I**
	Propulsion selection, jet engine integration, propeller engine integration, engine design considerations, engine size estimation, fuel system design and integration, landing gear and sub systems arrangements, guidelines and significance of design layout, report of initial specifications. Estimation of lift curve slope, maximum lift coefficient, complete drag builds up, installed performance of an engine, installed thrust methodology, net propulsive force, part power operation, aircraft structures and loads categories, air load distribution on lifting surfaces, review of methods of structural analysis, material selection, weights and moments statistical group estimation method, Centre of gravity excursion control.
MODULE IV	**BASELINE DESIGN ANALYSIS - II**
	Estimation of static pitch stability, velocity stability and trim, estimation of stability and control derivatives, static lateral, directional stability and trim. estimation of aircraft dynamical characteristics, handling qualities, Cooper – Harper scale, relation to aircraft dynamic characteristics, performance analysis and constraint analysis– steady level flight, minimum thrust required for level flight, range and loiter endurance, steady climbing and descending flight, best angle and rate of climb, time to climb and fuel to climb, level turning flight, gliding flight, energy maneuverability methods of optimal climb trajectories and turns, the aircraft operating envelope, take off analysis, balanced field length, landing analysis, fighter performance measures of merit, effects of wind on aircraft performance, initial technical report of baseline design analysis and evaluation, refined baseline design and report of specifications.
MODULE V	**COST ESTIMATION, PARAMETRIC ANALYSIS, OPTIMISATION, REFINED SIZING AND TRADE STUDIES**
	Elements of life cycle cost, cost estimating method, RDT and E and production costs, operation and maintenance costs, cost measures of merit, aircraft and airline economics, DOC and IOC, airline revenue, breakeven analysis, investment cost analysis, parametric analysis and optimization, improved conceptual sizing methods, sizing matrix plot and carpet plot, trade studies, design trades, requirement trades, growth sensitivities, multivariable design optimization methods, measures of merit, determination of final baseline design configuration, preparation of type specification report. Case studies on design of DC-3 and Boeing B-707 and 747; General dynamics F-16, SR-71 Blackbird, Northrop-Grumman B-2 Stealth Bomber.

TEXTBOOKS

1. Raymer, D.P., Aircraft Design: A Conceptual Approach, 3rd edn., AIAA Education Series, AIAA, 1999, ISBN: 1-56347-281-0.

2. Howe, D., Aircraft Conceptual Design Synthesis, Professional Engineering Publishing, London, 2000, ISBN: 1-86058-301-6.

3. Fielding, J.P., Introduction to Aircraft Design, Cambridge University Press, 2005, ISBN: 0-521- 657222-9.

REFERENCE BOOKS:

1. Krishnamurthy, C.S., ”Finite Element Analysis”, Tata McGraw Hill, 2000.
2. K. J. Bathe, E. L. Wilson, ”Numerical Methods in Finite Elements Analysis”, Prentice Hall of India, 1985.
3. Robert D Cook, David S Malkus, Michael E Plesha, ”Concepts and Applications of Finite Element Analysis”, 4th edition, John Wiley and Sons, Inc., 2003.
4. Larry J Segerlind, ”Applied Finite Element Analysis”, 2nd Edition, John Wiley and Sons, Inc.1084

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
1-2	Describe the basic Phases of aircraft design, aircraft conceptual design process, project brief / request for proposal, problem definition, information retrieval	CO1	T2: 1.1-1.5, T1: 4.1
3-4	Recall the integrated product development and aircraft design. initial conceptual sketches, takeoff gross weight estimation	CO1	T2: 2.1-2.2, R1: 3.1
5-6	Identify the airfoil selection, airfoil design,	CO1	T2: 2.3-2.4
7-8	Recall airfoil design considerations	CO1	T2: 2.5-2.6, R1: 3.3
9-10	Recognize the wing geometry and wing vertical location	CO2	T2: 3.3
11	Explain about wing tip shapes, tail geometry and arrangements	CO2	T2: 3.4, R1:4.1
12	Explain about trim tabs and types of trim tabs, static margin for stick fixed and stick free conditions.	CO2	T2: 3.4
13-14	explain the concept of thrust to weight ratio	CO2	T2: 3.3
15-16	Recognize thrust matching, wing.	CO3	T2: 4.2
17-18	Explain about the aircraft loading performance, constraint analysis.	CO3	T2: 5.1
19-20	Define about the aircraft Sizing with fixed engine and with rubber engine.	CO4	T2: 5.2
21-22	Estimate the aircraft geometry sizing of fuselage, wing, tail, control surfaces	CO4	T2: 5.3
23-24	Recognize description of surfaces.	CO5	T2: 4.5
25	Recall development of configuration lay out from conceptual sketch.	CO5	T1: 4.1
26	Define. the inboard profile drawing, lofting definition, significance and methods, flat wrap lofting, special consideration in configuration lay out.	CO5	T1: 4.2
27-28	Recognize Isobar tailoring, Sears-Haack volume distribution, structural load paths.	CO5	T2: 5.4, R1:6.1

29-30	Recall radar, IR, visual delectability, aural signature, considerations of vulnerability.	CO6	T2: 7.4
31	Describe Propulsion selection, jet engine integration, propeller engine integration, engine design considerations, engine size estimation, fuel system design and integration, landing gear and sub systems arrangements, guidelines and significance of design layout.	CO6	T2: 8.3
32	Explain report of initial specifications.	CO6	T2: 9.4, R1:7.1
33	Interpret description of installed performance of an engine, installed thrust methodology, net propulsive force, part power operation, aircraft structures and loads categories, air load distribution on lifting surfaces.	CO7	T2: 6.4
34	Estimation of review of methods of structural analysis, material selection, weights and moments statistical group estimation method, centre of gravity excursion control.	CO7	T2: 6.2
35-36	Estimation of static pitch stability, velocity stability and trim, estimation of stability and control derivatives, static lateral, directional stability and trim. estimation of aircraft dynamical characteristics, handling qualities, Cooper – Harper scale.	CO8	T2: 6.2
37-38	Identify liberalized relation to aircraft dynamic characteristics, performance analysis and constraint analysis– steady level flight	CO8	T2: 8.1
39-40	Inferred derivatives of minimum thrust required for level flight, range and loiter endurance, steady climbing and descending flight, best angle and rate of climb.	CO9	T2: 8.2
41-42	Identify Principle modes of time to climb and fuel to climb, level turning flight, gliding flight, energy maneuverability methods of optimal climb trajectories and turns.	CO9	T2: 8.3
43-44	Interpret undammed natural frequency and damping ratio, mode shapes, significance.	CO10	T2: 9.4, R1:4.1
45-46	Recall the aircraft operating envelope, take off analysis, balanced field length, landing analysis, fighter performance measures of merit.	CO10	T2: 9.4
47	State and apply effects of wind on aircraft performance, initial technical report of baseline design analysis and evaluation.	CO11	T2: 8.3
48-49	Explain refined baseline design and report of specifications.	CO11	T2: 8.2
50	Explain Elements of life cycle cost, cost estimating method, RDT and E and production costs, operation and maintenance costs, cost measures of merit, aircraft and airline economics.	CO11	T2: 9.1
51	DOC and IOC, airline revenue, breakeven analysis, investment cost analysis, parametric analysis and optimization, improved conceptual sizing methods.	CO11	T2: 9.2
52	Apply the concept of aircraft spin- entry, balance of forces in steady spin.	CO12	T1: 7.6
53	Explain sizing matrix plot and carpet plot, trade studies, design trades, requirement trades, growth sensitivities, multivariable design optimization methods.	CO12	T1: 7.5, R2:7.4

54	Explain the measures of merit, determination of final baseline design configuration, preparation of type specification report.	CO12	T1: 8.7
55	Case studies on design of DC-3 and Boeing B-707 and 747; General dynamics F-16, SR-71 Blackbird, Northrop-Grumman B-2 Stealth Bomber.	CO12	T1: 8.5, R2:9.5

Signature of Course Coordinator **HOD,AE**
Ms.K. Sai Priyanka,Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	CIVIL ENGINEERING				
Course Title	NON CONVENTIONAL ENERGY SOURCES				
Course Code	AEEB56				
Program	B, Tech				
Semester	VIII				
Course Type	Open Elective				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. K Devender Reddy, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB04	I	Basic Electrical and Electronics Engineering

II COURSE OVERVIEW:

This course envisages the renewable source of energy available in nature and to expose the students on sources of energy crisis, principle of operation of solar photo voltaic cell, different solar energy collectors and storage methods. It facilitates the study of wind turbines, geothermal energy, ocean, biomass, direct energy conversion systems. It concludes the knowledge of renewable energy resources for electrical applications

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Non Conventional Energy sources	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
%	Remember
50%	Understand
33.33%	Apply
16.66%	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

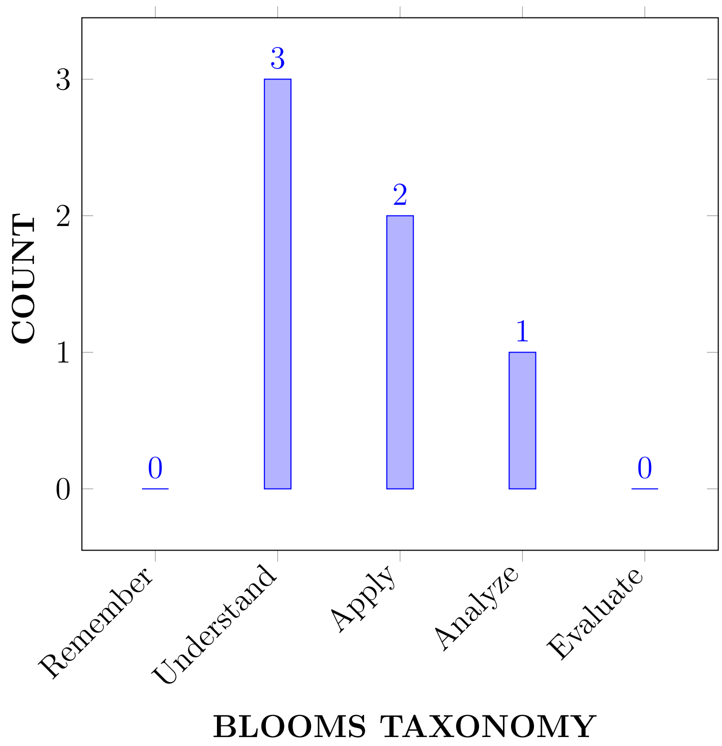
I	The environmental and economics related to renewable energy sources in comparison with fossil fuels.
II	The basic characteristics of renewable energy sources and technologies for their utilization.
III	The managerial skills to assess feasibility and drive strategies for alternative sources of energy.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Understand** the need of energy conversion and the various methods of energy storage .	Understand
CO 2	**Analyze** the major parameters of sun movement, solar radiation and tracking systems for calculation of solar insolation.	Analyze
CO 3	**Identify** different concentrating collectors for conversion of solar energy into thermal energy.	Apply
CO 4	**Explain** the concepts involved in wind energy conversion system using vertical and horizontal wind mills.	Understand
CO 5	**Illustrate** the operational methods of ocean and tidal energy for electrical energy conversion	Understand
CO 6	**Utilize** the mechanisms for direct energy conversion and geothermal energies into electricity.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations

Program Outcomes	
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	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

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	3	Assignments

3 = High; 2 = Medium; 1 = Low

X 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	-	-	✓	-	-	-	✓	-	-	-	-		-	-	-

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall the **basics of mathamatics, engineering sciences and other sciences** to understand energy storage methods	1
	PO 2	Understand the need of energy conversion using **basics fundamentals and engineering sciences.**	3
	PO 7	Understand the need of energy conversion using **basics fundamentals and engineering sciences.**	2
CO 2	PO 3	Analyze the major parameters of Sun tracking system for calculation of solar insolation for specified needs with appropriate consideration for the **public health, societal and environmental considerations**	3
	PO 7	Understand the need of energy conversion using **basics fundamentals and engineering sciences.**	2
CO 3	PO 2	Identify different concentrating collectors for conversion of solar energy into heat with the **knowledge of engineering sciences and mathematics**	3
	PO 7	Understand the need of energy conversion using **basics fundamentals and engineering sciences.**	2
CO 4	PO 1	Illustrate the concepts involved in wind energy conversion using **engineering fundamentals**	1
	PO 3	Explain the horizontal and vertical axis wind mills for specified needs with appropriate consideration for the **public health, societal and environmental** considerations.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 7	Understand the impact of the renewable energy sources on environment for **societal and sustainable development.**	2
CO 5	PO 3	Demonstrate the operational methods of ocean energy for electrical energy conversion for **public health, societal and environmental** considerations	3
	PO 7	Understand the impact of the renewable energy sources on environment for **societal and sustainable development**	2
CO 6	PO 3	Demonstrate the mechanisms for conversion of geothermal energies into electricity for **public health, societal and environmental considerations**	3
	PO 7	Understand the impact of the renewable energy sources on environment for **societal and sustainable development**	2

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	3	-	-	-	-	2	-	-	-	-		-	-	-
CO 2	-	-	3	-	-	-	2	-	-	-	-	-	-	-	-
CO 3	-	3	-	-	-	-	2	-	-	-	-	-	-	-	-
CO 4	-	-	3	-	-	-	2	-	-	-	-		-	-	-
CO 5	-	-	3	-	-	-	2	-	-	-	-	-	-	-	-
CO 6	-	-	3	-	-	-	2	-	-	-	-	-	-		-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	33.3	33.3	-	-	-	-	66.6	-	-	-	-		-	-	-
CO 2	-	-	33.3	-	-	-	66.6	-	-	-	-	-	-	-	-
CO 3	-	33.3	-	-	-	-	66.6	-	-	-	-	-	-	-	-
CO 4	-	-	33.3	-	-	-	66.6	-	-	-	-		-	-	-
CO 5	-	-	33.3	-	-	-	66.6	-	-	-	-	-	-	-	-
CO 6	-	-	33.3	-	-	-	66.6	-	-	-	-		-	-	-

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	1	-	-	-	-	3	-	-	-	-	-	-	-	
CO 2	-	-	1	-	-	-	3	-	-	-	-	-	-	-	-
CO 3	-	1	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 4	-	-	1	-	-	-	3	-	-	-	-	-	3	-	-
CO 5	-	-	1	-	-	-	3	-	-	-	-	-	-	-	-
CO 6	-	-	1	-	-	-	3	-	-	-	-	-	-	-	-
TOTAL	1	3	4	-	-	-	18	-	-	-	-	-	-	-	-
AVERAGE	1	1	1	-	-	-	3	-	-	-	-	-	-	-	-

XV ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments					

XVI ASSESSMENT METHODOLOGY-INDIRECT:

x	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVII SYLLABUS:

MODULE I	**PRINCIPLES OF SOLAR RADIATION**
	Role and potential of new and renewable source, the solar energy option, Environmental impact of solar power, physics of the sun, the solar constant, extraterrestrial and terrestrial solar radiation, solar radiation on titled surface, instruments for measuring solar radiation and sun shine, solar radiation data.
MODULE II	**SOLAR ENERGY COLLECTION AND SOLAR ENERGY STORAGE AND APPLICATIONS**
	Flat plate and concentrating collectors, classification of concentrating collectors, orientation and thermal analysis, advanced collectors. Different methods, Sensible, latent heat and stratified storage, solar ponds. Solar Applications- solar heating/cooling technique, solar distillation and drying, photovoltaic energy conversion
MODULE III	**WIND ENERGY AND BIO-MASS**
	Wind Energy: Sources and potentials, horizontal and vertical axis windmills, performance characteristics, Betz criteria. Bio-Mass: Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, utilization for cooking, I.C. Engine operation and economic aspects.

MODULE IV	GEOTHERMAL ENERGY AND OCEAN ENERGY
	Geothermal Energy: Resources, types of wells, methods of harnessing the energy, potential in India Ocean Energy: OTEC, Principle's utilization, setting of OTEC plants, thermodynamic cycles. Tidal and wave energy: Potential and conversion techniques, mini-hydel power plants, and their economics.
MODULE V	DIRECT ENERGY CONVERSION
	Need for DEC, Carnot cycle, limitations, principles of DEC

TEXTBOOKS

1. G.D. Rai, "Non-Conventional Energy Sources", TMH, 3rd Edition 2009.
2. Twidell & Weir, "Renewable Energy Sources", CRC Press, 1st Edition, 2008.
3. Renewable Energy sources and emerging technologies by D.P. Kothari, K.C. Singhal

REFERENCE BOOKS:

1. John Twidell, "Renewable Energy Resources" Taylor & Francis group, 4th Edition
2. G. N. Tiwari and M K. Ghosal, "Renewable Energy Resources" Narosa Publishing House, 2004
3. K.M. Mital, "Non-conventional Energy Systems" A H Wheeler Publishing Co Ltd, 1999

WEB REFERENCES:

1. https://nptel.ac.in/courses/112105171/1

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=pages/btech-course-descriptions-iare-r18-0

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Lecture on Outcome Based Education.		
CONTENT DELIVERY (THEORY)			
2	Role and potential of renewable energy sources	CO 1	T1: 1.2
3	Environmental impacts of solar power	CO 1	T1: 1.4
4	Physics of the sun, solar constant	CO 2	T1: 2.2
5	Solar radiation and solar radiation on titled surface	CO 2	T1: 2.4
6	Instruments for measuring solar radiation, sun shine and solar radiation data	CO 2	T1: 2.6
7	Pyranometer and pyrheliometer	CO 2	T1: 2.6
8	Flat plate collectors	CO 3	T1: 3.3
9	Parabolic trough collector and power tower receiver	CO 3	T1: 3.7
10	Parabolic dish and Fresnel lens collector	CO 3	T1: 3.7
11	Solar heating methods	CO 3	T1: 4.2

12	Solar pond	CO 1	T1: 4.3
13	Solar photovoltaic cell	CO 1	T1: 4.3
14	Applications of solar energy	CO 3	T1: 5.2
15	Solar distillation and drying	CO 1	T1: 5.8
16	Source and potential of wind energy and horizontal axis wind mill	CO 4	T1: 6.2-6.8
17	Vertical axis wind mill and Betz criteria	CO 4	T1: 6.8
18	Principle of Bio- conversion and anaerobic digestion	CO 1	T1: 7.2
19	Fixed dome biogas plants	CO 1	T1: 7.9
20	Floating drum biogas plants	CO 1	T1: 7.9
21	Low-cost polyethylene tube digester	CO 1	T1: 7.10
22	Balloon biogas plants	CO 1	T1: 7.10
23	Horizontal biogas plants	CO 1	T1: 7.10
24	Earth-pit biogas Plants	CO 1	T1: 7.10
25	Ferro-cement biogas Plants	CO 1	T1: 7.10
26	Industrial Digester	CO 1	T1: 7.10
27	Combustion characteristics of bio-gas	CO 1	T1: 7.24
28	Bio gas utilization for cooking	CO 1	T1: 7.24
29	I.C. Engine operation and economic aspects	CO 1	T1: 7.24
30	Geothermal sources	CO 6	T1: 8.1
31	Types of wells	CO 6	T1: 8.16
32	Geothermal harnessing methods	CO 6	T1: 8.10
33	OTEC principles	CO 5	T1: 9.2
34	Utilization of OTEC plants	CO 5	T1: 9.2
35	Setting of OTEC plants	CO 5	T1: 9.5
36	Thermodynamic cycles	CO 5	T1: 9.3
37	Tidal energy potential and conversion techniques	CO 5	T1: 9.3
38	Wave energy potential and conversion techniques	CO 5	T1: 9.4
39	Mini-hydel power plants and their economics	CO 5	T1: 9.5
40	Principles of DEC	CO 6	T1: 10.1
41	Carnot cycle	CO 6	T1: 10.2
DEFINATIONS AND TERMINOLOGY			
42	Role and potential of various renewable energy source	CO 1	T1, R1
43	Physics of sun and various solr collectors	CO2, 3	T1, R1
44	Wind and biomass energy conversion systems	CO 4	T1, R1
45	Operational methods of ocean and tidal energy conversion systems	CO5	T1, R1
46	Direct and geothermal energy conversion systems	CO 6	T1, R1

TUTORIAL QUESTION BANK			
47	Principle of Solar Radiation	CO 1, 02	T1, R1
48	Solar Energy Collection and Solar Energy Storage and Applications	CO3	T1, R1
49	Wind Energy and Bio mass	CO4	T1, R1
50	Geothermal Energy and Ocean Energy	CO5, 06	T1, R1
51	Direct Energy Conversion	CO 6	T1, R1

Signature of Course Coordinator **HOD,CE**