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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**ENGLISH**				
Course Code	AHSC01				
Program	B. Tech				
Semester	I				
Course Type	Foundation				
Regulation	UG-20				
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:

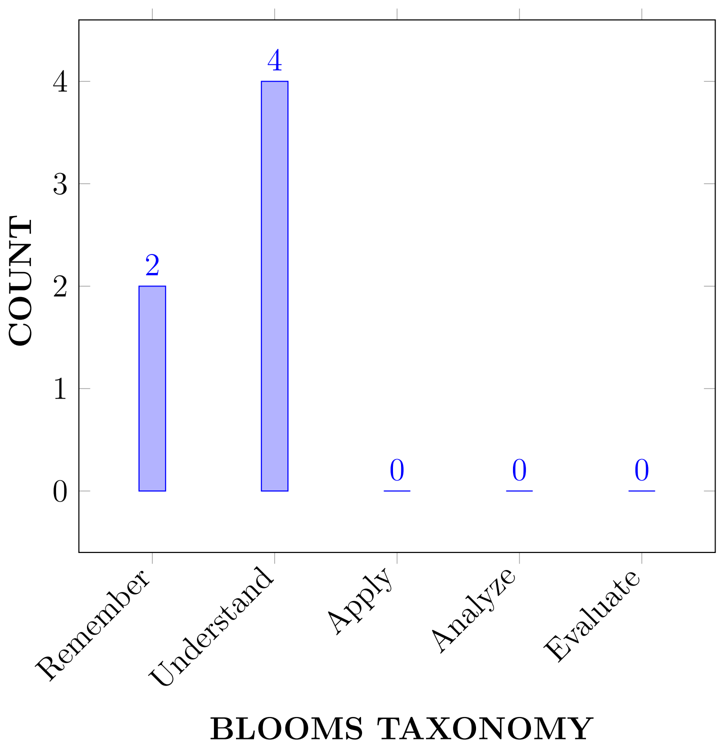
I	Standard pronunciation, appropriate word stress, and necessary intonation patterns for effective communication towards achieving academic and professional targets.
II	Appropriate grammatical structures and also using the nuances of punctuation tools for practical purposes.
III	A critical aspect of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

VII COURSE OUTCOMES:

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

CO 1	**Discuss** the prime necessities of listening skill for academic and non-academic purposes.	Remember
CO 2	**Illustrate** appropriate speaking strategies to explain a topic in a clear-cut manner.	Understand
CO 3	**Choose** acceptable language for developing life skills to overcome the challenges at professional platform.	Understand
CO 4	**Interpret** the grammatical aspects effectively in speaking and writing at functional usage.	Understand
CO 5	**Describe** the importance of reading skill and various strategies to enhance professional growth and success.	Remember
CO 6	**Summarize** writing skills for fulfilling the academic and non-academic requirements of various written communicative functions.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	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 10	Discuss the heeds of functional grammar and punctuation tools in speaking and writing by generating the clarity of an audio text.	5
CO 2	PO 10	Illustrate essential aspects of grammar as well as punctuation marks for speaking or writing towards a discussion on a topic to give the clarity.	5
CO3	PO 10	Choose suitable grammatical structures and punctuation marks at speaking and writing areas maintaining clarity at professional platform.	5
CO4	PO 10	Interpret the grammatical knowledge and punctuation marks systematically towards providing the clarity in speaking and writing.	5
CO5	PO 10	Demonstrate the role of grammar and punctuation marks understanding the meaning between the sentences as well as paragraphs in speaking or writing for a clarity.	5
CO6	PO 10	Describe the clarity of grammatical usage and the obligation of punctuation marks in speaking and writing.	5

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

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

TEXTBOOKS

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

REFERENCE BOOKS:

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

XIX COURSE PLAN:

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

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

35	Organizing principles of a paragraph in documents and types of paragraphs.	CO 5	T1:101.103
36	Writing introduction and conclusion.	CO 5	T1:103.103
37	Techniques for writing precis.	CO 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
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COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**LINEAR ALGEBRA AND CALCULUS**				
Course Code	AHSC02				
Program	B.Tech				
Semester	I				
Course Type	Foundation				
Regulation	UG - 20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. P Shantan Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

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

II COURSE OVERVIEW:

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

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

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

Continuous Internal Assessment (CIA):

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CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
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Total Marks			100

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

Alternative Assessment Tool (AAT)

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

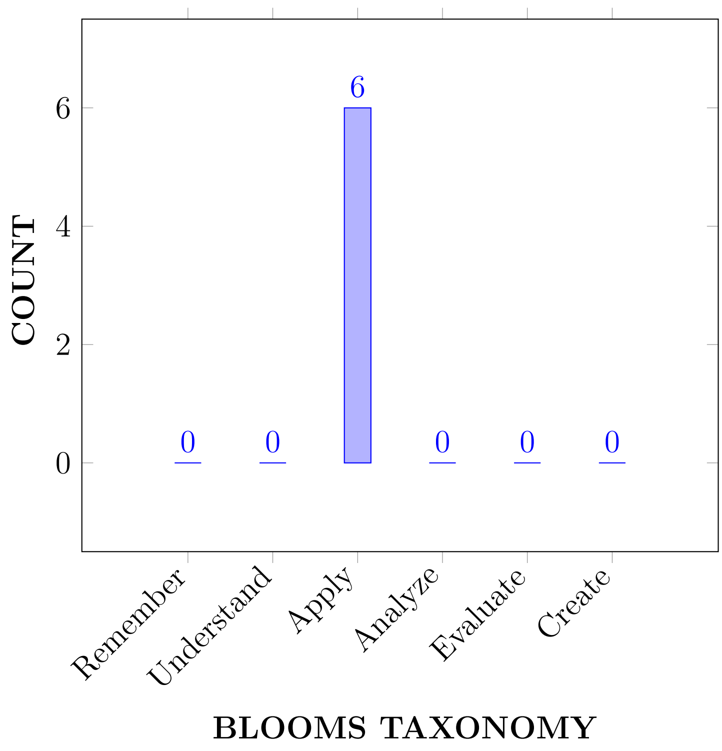
I	The principles of Eigen value analysis and linear transformations, Matrix rank finding methods.
II	The calculus of functions of several variables and the concept of maxima-minima for a three-dimensional surface.
III	The analytical methods for solving higher order differential equations with constant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

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



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PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 1	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards	-	-
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 design, computational and experimental tools for research and innovation in aerospace technologies and allied streams, to become successful professional, entrepreneurs and desire higher studies.	-	-

3 = High; 2 = Medium; 1 = Low

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

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

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

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

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

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

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

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

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

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

COURSE 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	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	9	-	-	-	-	-	-	-	-	-	-	-	-	-
AVERAGE	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

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

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

TEXT BOOKS

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

REFERENCE BOOKS:

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

WEB REFERENCES:

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

COURSE WEB PAGE:

1. lms.iare.ac.in

XIX COURSE PLAN:

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

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

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

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

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

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

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION

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

I COURSE PRE-REQUISITES:

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

II COURSE OVERVIEW:

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

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

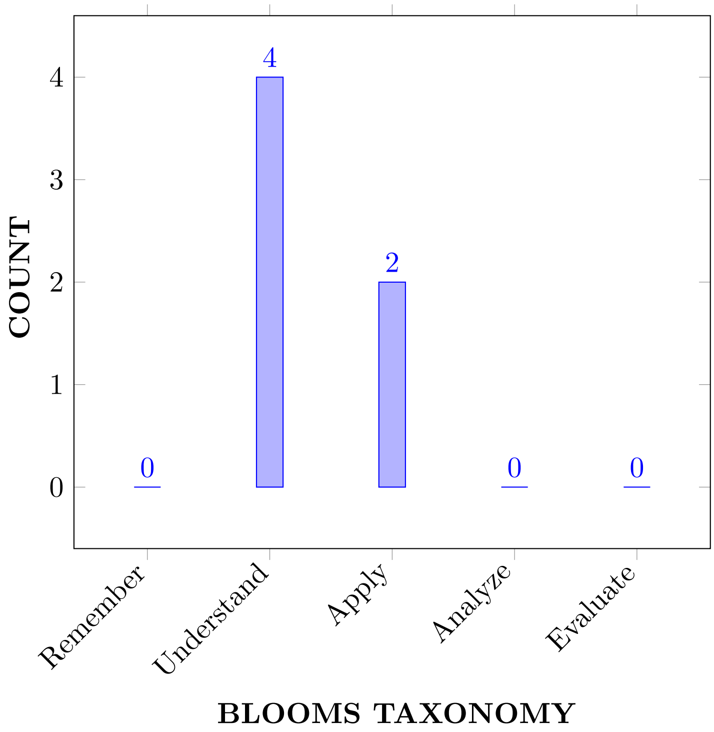
I	Basic formulations in wave mechanics for the evolution of energy levels and quantization of energies for a particle in a potential box with the help of mathematical description.
II	Fundamental properties of semiconductors including the band gap, charge carrier concentration, doping and charge carrier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

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of multi physics,computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	1	Laboratory experi-ments

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH POs, PSOs:

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

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

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

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

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

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

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

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

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

XVI ASSESSMENT METHODOLOGY DIRECT:

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

XVII ASSESSMENT METHODOLOGY INDIRECT:

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

XVIII SYLLABUS:

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

TEXTBOOKS

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

REFERENCE BOOKS:

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

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	
CONTENT DELIVERY (THEORY)			
2	Introduction to quantum physics- Black body radiation, Planck's law, Photoelectric effect, Compton effect	CO 1	T1:6.1 R1:1.12.1,
3	De-Broglie's hypothesis,	CO 1	T1:6.3 R1:1.16
4	Wave-particle duality -Matter wave concept	CO 1	T1:6.2 R1:1.13.1
5	Davisson and Germer experiment	CO 1	T1:6.4.1 R1:1.13.2
6	Time-independent Schrodinger equation for wave function	CO 1	T1:6.6 R1:1.13.3
7	Born interpretation of the wave function	CO 1	T1:6.6.1 R1:1.17.1
8	Schrodinger equation for one -dimensional problems– particle in a box.	CO 1	T1:6.7 R1:1.17.3
9	Introduction to classical free electron theory & quantum theory.	CO 2	T1:7.2 R1:1.17.3
10	Bloch's theorem for particles in a periodic potential,	CO 2	T1:7.4 R1:2.3
11	Kronig-Penney model (Qualitative treatment)	CO 2	T1:7.5 R1:2.3
12	Types of electronic materials: metals, semiconductors, and insulators	CO 2	T1:7.6,7.7 R1:2.6.2
13	Intrinsic semiconductors - concentration of electrons in conduction band.	CO 2	T1:8.3.1 R1:2.8
14	Intrinsic semiconductors - concentration of holes in valence band	CO 2	T1:8.3.2 R1:2.9.2
15	Extrinsic semiconductors- Carrier concentration in N-Type	CO 2	T2:8.5 R1:2.10
16	Extrinsic semiconductors- Carrier concentration in P-Type	CO 2	T1:8.6 R1:2.10
17	Dependence of Fermi level on carrier-concentration and temperature	CO 2	T1:8.5,8.6 R1:2.10.2
18	Hall effect	CO2	T1:8.9 R1:2.32
19	Introduction and characteristics of LASER	CO 3	T1:12.1. R1:8.2
20	Spontaneous and stimulated emission of radiation,Meta stable state, Population inversion, Lasing action	CO 3	T1:12.2 R1:8.3.3
21	Ruby laser,He-Ne laser	CO 3	T1:12.3,12.8 R1:8.7.2

22	Applications of LASER	CO 3	T1:12.8.12.9 R1:8.7.2
23	Principle and construction of an optical fiber	CO 4	T1:13.2 R2:12.24
24	Acceptance angle, Numerical aperture	CO 4	T1:13.2 R3:12.25
25	Types of optical fibers (Single mode, multimode, step index, graded index)	CO 4	T1:13.3 R3:3.2
26	Optical fiber communication system with block diagram	CO 4	T1:13.7 R3:3.2
27	Applications of optical fibers .	CO 4	T1:13.12 R1:8.10
28	Principle of Superposition of waves	CO 5	T4:4.3 R1:8.11.1
29	Young's double slit experiment	CO 5	T4:4.7 R1:8.11.2
30	Newton's rings	CO 5	T4:4.14 R1:8.12.1
31	Fraunhofer diffraction from a single slit	CO 5	T4:4.19 R1:8.12.2
32	Fraunhofer diffraction from a Double slit	CO 5	T4:4.21 R1:8.20
33	Fraunhofer diffraction from diffraction grating	CO 5	T4:4.22 R1:8.19
34	Simple Harmonic Oscillators	CO 6	T4:2.3 R1:8.77
35	Damped harmonic oscillator	CO 6	T4:2.8,2.9 R1:7.2
36	Forced mechanical oscillators	CO 6	T4:2.14 R1:7.7
37	Impedance, Steady state motion of forced damped harmonic oscillator	CO 6	T4:2.17 R1:7.8
38	Transverse wave on a string, the wave equation on a string	CO 6	T4:3.3 R1:7.9.2
39	Longitudinal waves and the wave equation	CO 6	T4:3.7 R1:7.9.1
40	Reflection and transmission of waves at a boundary	CO 6	T4:3.4 R1:7.10
41	Harmonic waves	CO 6	T4:3.6 R1:7.11, 11.1
PROBLEM SOLVING/ CASE STUDIES			
1	De-Broglie hypothesis-wavelength expression	CO 1	T1:6.3 R1:1.161
2	Schrodinger equation for one dimensional problems–particle in a box.	CO 1	T1:6.6 R1:1.161
3	Physical significance of the wave function	CO 1	T1: 6.6.1 R1:1.161.
4	Carrier concentration	CO 2	T1:8.3-6, R1:2.8,2.10

5	Fermi level	CO 2	T1:8.5,8.6 R1: 2.10
6	Hall Effect	CO 2	T1:8.9, R1: 2.32
7	Lasers	CO 3	T1: 12.3 R3:12.26
8	Acceptance angle & Numerical aperture	CO 4	T1: 13.2 R3:12.26
9	Refractive indices of core and cladding, fractional refractive index change	CO 4	T1: 13.3 R3:12.26
10	Youngs double-slit	CO 5	T4: 4.7 R1:8.12.1
11	Fringe width	CO 5	T4: 4.7 R1:8.12.1
12	Newton rings	CO 5	T4: 4.14 R1:8.12.1
13	Diffraction grating	CO 5	T4: 4.22 R1:8.12.1
14	Simple Harmonic Oscillator	CO 6	T4:2.3 R1: 8.78
15	Harmonic waves	CO 6	T4:3.6 R1: 7.9.3
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Quantum mechanics	CO 1	T1:6.1-6.7 R1:1.161.
2	Introduction to Solids and Semiconductors	CO 2	T1:7.2-7, 8.3-9 , R1: 2.8, 2.10
3	Lasers and Fiber Optics	CO 3, CO 4	T1: 12.1-12.9,13.2-13.12 R3:12.26
4	Light and Optics.	CO 5	T4: 4.3-4.22 R1:8.12.1
5	Harmonic Oscillations and Waves in One Dimension	CO 6	T4:2.3-3.7 R1: 8.78, 7.9.3
DISCUSSION OF QUESTION BANK			
1	Module 1	CO 1	T1:6.1-6.7 R1:1.161.
2	Module 2	CO 2	T1:6.1-6.7 R1: 2.8, 2.10

3	Module 3	CO 3, CO 4	T1: 12.1-12.9,13.2-13.12 R3:12.26
4	Module 4	CO 5	T4: 4.3-4.22 R1:8.12.1
5	Module 5	CO 6	T4:2.3-3.7 R1: 8.78, 7.9.3

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

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

COURSE DESCRIPTION

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

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	ACSC01	I	NIL

II COURSE OVERVIEW:

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

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

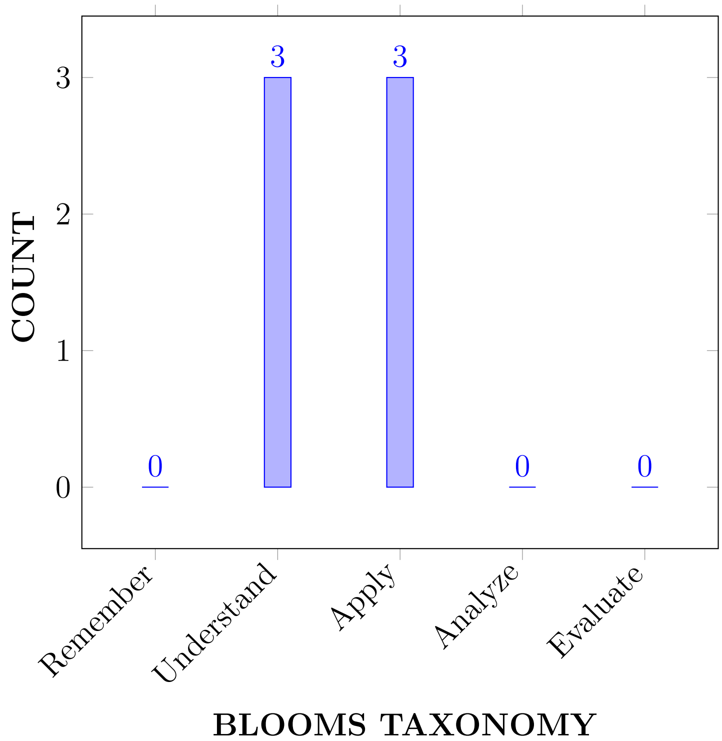
I	**Acquire programming skills in core Python**
II	**Acquire Object-oriented programming skills in Python.**
III	**Develop the skill of designing graphical-user interfaces (GUI) in Python.**
IV	**Develop the ability to write database applications in Python.**
V	**Acquire Python programming skills to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

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PSO 1	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.	3	Tech talk /Open ended experiments
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	Tech talk /Open ended experiments

3 = High; 2 = Medium; 1 = Low

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

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

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

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

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

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

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

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

TEXTBOOKS:

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

REFERENCE BOOKS:

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

COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
	Discussion on mapping COs with POs. (OBE)		
CONTENT DELIVERY (THEORY)			
1-2	Introduction to Python: Features of Python, History and Future of Python	CO 1	T1:3.1 –3.3
3-4	Working with Python – interactive and script mode, Identifiers and Keywords, Comments, Indentation and Multi-lining, Databtypes – built-in data types	CO 1	T1:3.4-3.9
5-8	Operators and Expressions	CO 1	T1:3.12
9-10	Console Input/Output, Formatted printing, Built-in Functions, Library Functions	CO 1	T1:3.15
11-14	Control Statement(s)	CO 2	T1: 4.1 –4.8
15-17	Lists and Tuples	CO 3	T1:3.15
18-19	Conversion of List comprehension to Tuple, Iterators and Iterables, zip() function	CO 3	T1:3.15
20-21	Sets, Dictionaries:	CO 3	T1:3.15
22-23	Nested Dictionary, Dictionary comprehension	CO 3	T1:3.15
24-25	Strings: Accessing string elements, string properties, string operations	CO 4	T1: 6.1 –6.8
26-27	Functions: Communicating with functions, Variable Scope and lifetime, return statement	CO 5	T1:5.1 –5.5

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

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

Course Coordinator
B Dilip Chakravarty

HOD CSE(CS)

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

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

I COURSE OVERVIEW:

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

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Sofware based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

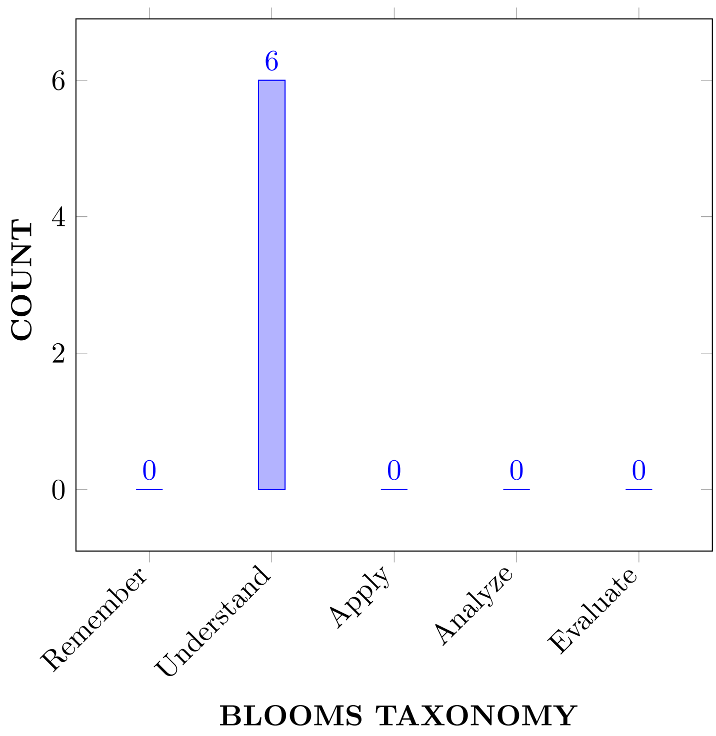
I	Facilitate computer-assisted multi-media instructions to make possible individualized and independent language learning.
II	The critical aspect of speaking and reading for interpreting in-depth meaning of the sentences.
III	Use language appropriately for social interactions such as public speaking,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

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	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. M.Sailaja, Associate Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

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

I COURSE OVERVIEW:

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

II COURSE PRE-REQUISITES:

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

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

A. Experiment Based

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

B. Programming Based

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

VI COURSE OBJECTIVES:

The students will try to learn:

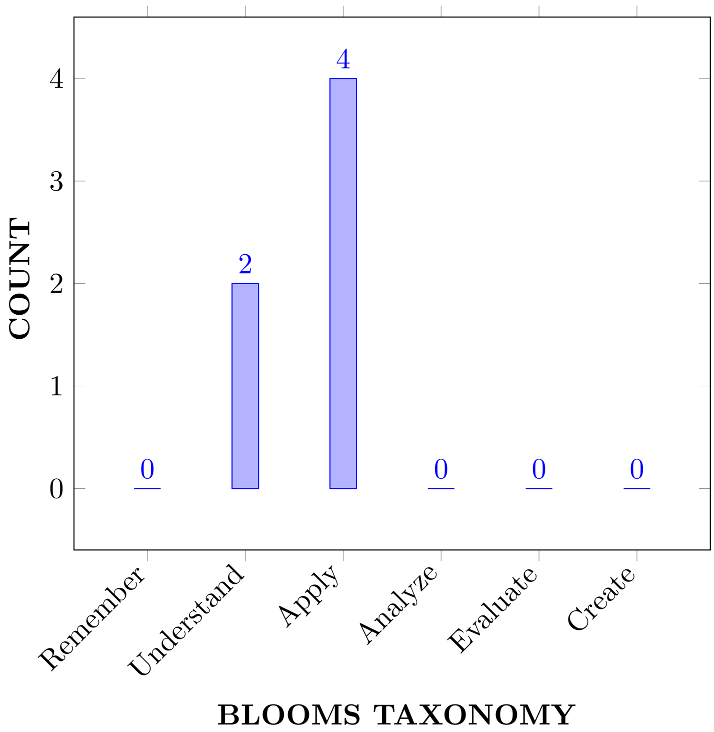
I	To familiarize with the lab facilities, equipment, standard operating procedures.
II	About the different kinds of functional electric and magnetic materials which paves a way for them to use in various technical and engineering applications.
III	The analytical techniques and graphical analysis to study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

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies	1	Laboratory experiments and Surveys

3 = High; 2 = Medium; 1 = Low

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

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

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

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

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

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

3 = High; 2 = Medium; 1 = Low

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

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

TEXTBOOKS

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

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

REFERENCE BOOKS:

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

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

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Determination of charge carrier density.	CO 1	T1:13.5
2	Determination of frequency of a given tuning fork.	CO 2	T1:13.5
3	Determination of Magnetic field along the axis of current carrying coil – Stewart and Gee's method.	CO 3, CO 4	TT1:14.7
4	Determination of the energy loss per unit volume of a given magnetic material per cycle by tracing the Hysteresis loop.	CO 3	T1:15.7
5	Determination of energy gap of a semiconductor diode.	CO 1	T1:16.8
6	Studying V-I Characteristics of Photo Diode.	CO 6	T1:16.9
7	Evaluation of numerical aperture of a given optical fiber.	CO 4	T1:17.9
8	Determination of wavelength of a given laser light using diffraction grating.	CO 5	T1:18.10
9	Determination of Plank's constant using LED.	CO 6	T1:19.10
10	Studying V-I characteristics of LED	CO 6	T1:19.9
11	Determination of radius of curvature of a given Plano-convex lens.	CO 5	T1:23.10
12	Determination of width of a given single slit.	CO 5	T1:23.10

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

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

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

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

AERONUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**PYTHON PROGRAMMING LABORATORY**				
Course Code	ACAC02				
Program	B.Tech				
Semester	I	AE			
Course Type	Core				
Regulation	IARE - UG 20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Ms Jalaja Vishnubhotla, Assistant Professor CSE (AI&ML)				

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

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSC02	I	-

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
PYTHON PROGRAMMING LABORATORY	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

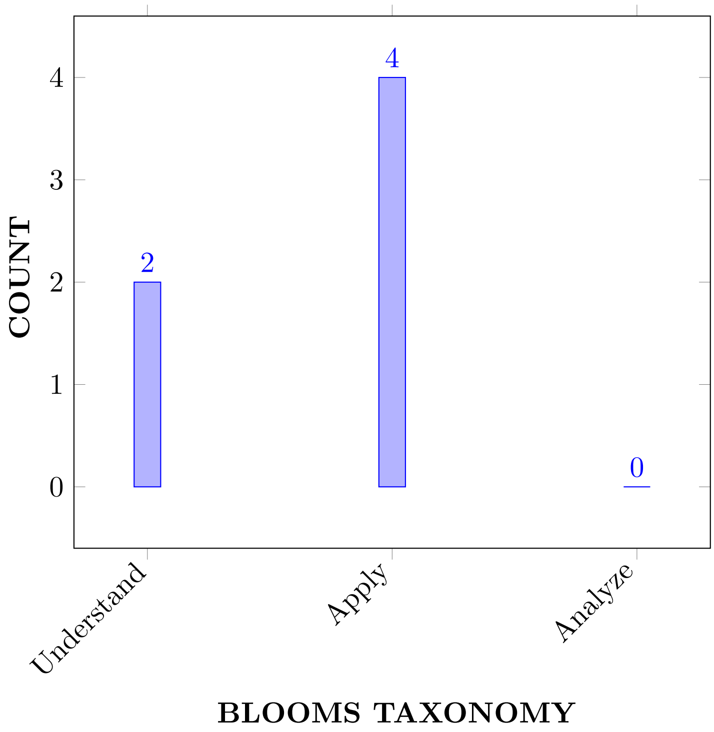
VII COURSE OUTCOMES:

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

CO 1	**Demonstrate** the basic concepts of python programming with the help of data types, operators and expressions, console input/output	Understand
CO 2	**Make use of** control statements for altering the sequential execution of programs in solving problems.	Apply
CO 3	**Demonstrate** operations on built-in container data types (list, tuple, set, dictionary) and strings.	Understand

CO 4	**Make use of** operations and applications on strings with the help of built in functions	Apply
CO 5	**Solve** the problems by using modular programming concepts through functions.	Apply
CO 6	**Identify** object-oriented programming constructs for developing large, modular and reusable real-time programs	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

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.	3	Lab Exercises
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	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	Demonstrate the data types of Python Programming by understating their importance and applicability (apply) in. **solving (complex) engineering problems by applying the principles of Mathematics and Engineering.**	3
	PO 2	Demonstrate the data types of Python Programming **with provided information and data in reaching substantiated conclusions by the interpretation of results.** .	3

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

	PSO 3	Understand the concept of modularity by implementing different user defined and built functions **from real world problems to visualize the data to analyze the complexity.**.	3
CO 6	PO 1	Apply the knowledge of **engineering fundamentals**, and an **Mathematics and Engineering fundamentals principles to create a object oriented model on real time problems**.	3
	PO 3	Apply object oriented and modular concepts on **solving real world problems** reaching **and reusable conclusions**.	3
	PSO 3	Use built in functions in Python **for solving modular and reusable real time problems**.	3

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

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

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

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

	a.Write a program to generate and print a dictionary that contains a number (between 1 and n) in the form (x, x*x). b.Write a program to perform union, intersection and difference using Set A and Set B. c.Write a program to count number of vowels using sets in given string (Input : "Hello World", Output: No. of vowels : 3) d.Write a program to form concatenated string by taking uncommon characters from two strings using set concept (Input : S1 = "aacdb", S2 = "gafd", Output : "cbgf").
WEEK 6	**DICTIONARY**
	a. Write a program to do the following operations: i. Create a empty dictionary with dict() method ii. Add elements one at a time iii. Update existing keys value iv. Access an element using a key and also get() method v. Deleting a key value using del() method b. Write a program to create a dictionary and apply the following methods: i. pop() method ii. popitem() method iii. clear() method c.Given a dictionary, write a program to find the sum of all items in the dictionary
WEEK 7	**STRINGS**
	a. Given a string, write a program to check if the string is symmetrical and palindrome or not. A string is said to be symmetrical if both the halves of the string are the same and a string is said to be a palindrome string if one half of the string is the reverse of the other half or if a string appears same when read forward or backward. b. Write a program to read a string and count the number of vowel letters and print all letters except 'e' and 's'. c. Write a program to read a line of text and remove the initial word from given text. (Hint: Use split() method, Input : India is my country. Output : is my country) d. Write a program to read a string and count how many times each letter appears. (Histogram)
WEEK 8	**USER DEFINED FUNCTIONS**
	a. A generator is a function that produces a sequence of results instead of a single value. Write a generator function for Fibonacci numbers up to n. b.Write a function mergedict(dict1, dict2) to merge two Python dictionaries. c.Write a fact() function to compute the factorial of a given positive number. d.Given a list of n elements, write a linearsearch() function to search a given element x in a list.
WEEK 9	**BUILT-IN FUNCTIONS**

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

TEXTBOOKS

1. Michael H Goldwasser, David Letscher, “Object Oriented Programming in Python”, Prentice Hall, 1st Edition, 2007.
2. Yashavant Kanetkar, Aditya Kanetkar, “Let us Python”, BPB publication, 1st Edition, 2019

3. Ashok Kamthane, Amit Kamthane, "Programming and Problem Solving with Python", McGraw Hill Education (India) Private Limited, 2018.
4. Taneja Sheetal, Kumar Naveen, "Python Programming – A modular approach", Pearson, 2017

REFERENCE BOOKS:

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

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	Operators	CO 1	R1: 1
2	Control structures	CO 1	R3: 2
3	List	CO 2	R1: 7
4	Tuple	CO 2	R1: 8
5	Set	CO 3	R1: 2.4
6	Dictionary	CO 3	R1: 9
7	Strings	CO 4	R1: 10
8	User Defined Functions	CO 4	R3: 15
9	Built in Functions	CO 5	R1: 9
10	Class and Objects	CO5	R1: 10
11	Miscelaneous Programs	CO 6	R4:7
12	Additionaal programs - File Handling	CO 6	R4:10

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

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

Signature of Course Coordinator **HOD, CSE(AI&ML)**
Ms Jalaja Vishnubhotla, Assistant Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

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

I COURSE PRE-REQUISITES:

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

II COURSE OVERVIEW:

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

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

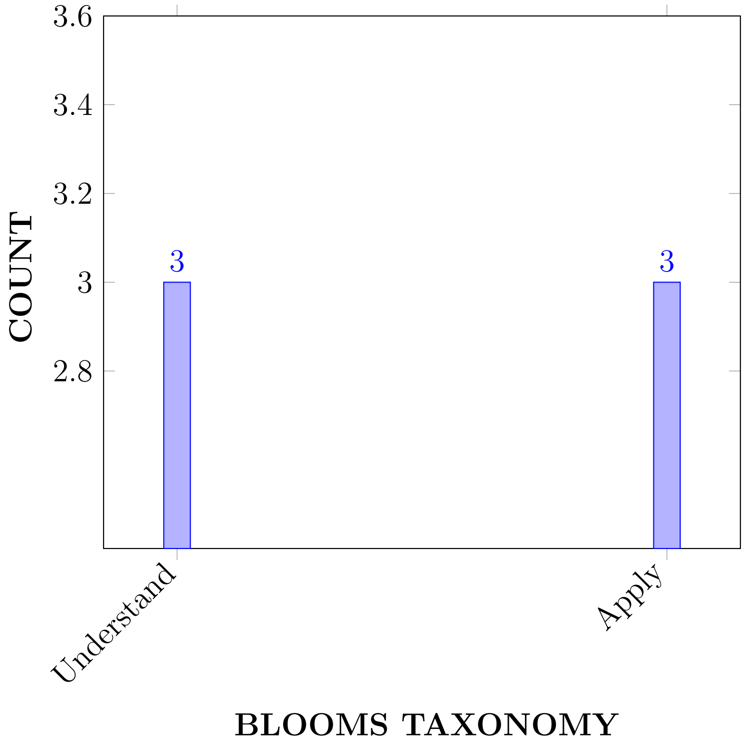
I	The concepts of electrochemical principles and causes of corrosion in the new development and breakthroughs efficiently in engineering and technology.
II	The different parameters to remove causes of hardness of water and their reactions towards the complexometric method.
III	The polymerization reactions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

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	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

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

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

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

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

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

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

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

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

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

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

XVI ASSESSMENT METHODOLOGY DIRECT:

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

XVII ASSESSMENT METHODOLOGY INDIRECT:

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

XVIII SYLLABUS:

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

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

TEXTBOOKS

1. P. C. Jain and Monica Jain, “Engineering Chemistry”, Dhanpat Rai Publishing Company, 16th Edition, 2017.
2. Shashi Chawla, “Engineering Chemistry”, Dhanat Rai and Company, 2011, 1st Edition.
3. Prashanth rath, B.Rama Devi, Ch.Venkata Ramana Reddy, Subhendu Chakroborty, Cengage Learning Publishers, 1st Edition, 2018
4. Anubha Kaushik, C.P.Kaushik, “Environmental Studies” New Age International publishers, 4th Edition, 2015.
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1. 1. Dr.Bharathi Kumari, “A text book of Engineering Chemistry”, VGS Book Links, 8th Edition,2016.
2. 2. B. Siva Shankar, “Engineering Chemistry”, Tata McGraw Hill Publishing Limited, 3rd Edition, 2015.
3. 3. S. S. Dara, Mukkanti, “Text of Engineering Chemistry”, S. Chand Co, New Delhi, 12thEdition, 2006.

XIX COURSE PLAN:

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	W1
CONTENT DELIVERY (THEORY)			
1	Outcome Based Education.		
2	Recall the concept of electro chemical cells.	CO 1	T1:6.1,R1: 2.6

3	Explain the electrode potential, standard electrode potential, electrochemical series and its applications.	CO 2	T1:6.2,R1: 2.9
4	Derive Nernst equation , numerical problems on cell potential.	CO 2	T1:6.5,R1: 2.6.3
5	Demonstate about calomel electrode. Batteries: primary (dry cell).	CO 1	T1: 6.7, R1:2.12
6	Explain the secondary batteries (Lead-acid storage battery), Li-ion battery.	CO 1	T1:6.12,R1: 2.12
7	Recognize the causes and effects of corrosion, chemical corrosion.	CO 1	T1:7.1, R1:2.14
8	Explain the electrochemical corrosion, mechanism of electrochemical corrosion.	CO 1	T1:7.2, R1:2.17
9	Explain about cathodic protection, sacrificial anode and impressed current.	CO 1	T1:7.14, R1:2.20
10	Apply metallic coatings, methods of coatings, hot dipping, galvanizing , tinning and electroplating.	CO 1	T1:7.14,R1: 2.22
11	Recall the hardness of water, causes of hardness.	CO 3	T1:1.3,R1: 1.4
12	Explain the types of hardness, temporary and permanent, units of hardness.	CO 3	T1:1.3,1.5, R1:1.6.1,1.6.3
13	Estimation of hardness of water by complexometric method,	CO 3	T1:1.5,R1: 1.6.2
14	Estimation of hardness of water by complexometric method.	CO 3	T1:1.14,R1: 1.6.4
15	Define potable water and its specifications, steps involved in treatment of water, disinfection of water by chlorination and ozonization.	CO 3	T1:1.12,R1: 1.6.5
16	Explain about external treatment of water; ion-exchange process.	CO 3	T1:1.11, R1:1.8.1
17	Explain about desalination of water: reverse osmosis.	CO 3	T1:1.13, R1:1.10
18	Recall polymers-classification with examples and Explain about the polymerization-addition, condensation and co- polymerization	CO 4	T1: 3.5,R1: 3.1
19	Explain the concept of compounding of plastics.	CO 4	T1:1.4, R1: 3.1.4
20	Expalin the preparation, properties and applications of polyvinyl chloride, teflon.	CO 4	T1:3.5,R1: 3.2
21	Explain the bakelite and nylon-6, 6.	CO 4	T1: 3.12,R1: 3.2.2
22	Define biodegradable polymers, synthetic biodegradable polymers.	CO 4	T1:3.14,R1: 3.2.3
23	Explain rubbers, natural rubber its process and vulcanization, Buna-s and thiokol rubber.	CO 4	T1: 3.15, R1:3.2.3
24	Elastomers: Synthetic rubbers,Buna-s and thiokol rubber.	CO 4	T1: 3.22, R1:3,3.4
25	Lubricants: characteristics of lubricants, mechanism of lubrication – thick film, thin film, extreme pressure lubrication.	CO 4	T1: 3.24,R1: 3.5

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

50	Problems on the total hardness in terms of calcium carbonate equivalents by using EDTA method.	CO 3	T1:1.5,R1: 1.6.2
51	Problems on the permanent hardness in terms of calcium carbonate equivalents by using EDTA method.	CO 3	T1:1.14,R1: 1.6.4
52	Problems on the temporary hardness in terms of calcium carbonate equivalents by using EDTA method.	CO 3	T1:1.5,R1: 1.6.2
53	Problems on the higher and lower calorific values of the fuel.	CO 5	T1:4.8, R1:5.2
54	Problems on the gross and net calorific values of the fuel.	CO 5	T1:4.8, R1:5.2
55	Problems on HCV and LCV	CO 5	T1:4.8, R1:5.2
56	Problems on GCV and NCV	CO 5	T1:4.8, R1:5.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Definitions & terminology discussion on electrochemistry and corrosion	CO 1 ,CO 2	T1:1.3,R1: 1.4
58	Definitions & terminology discussion on water technology	CO 3	T1: 3.5,R1: 3.1
59	Definitions & terminology discussion on engineering	CO 4	T1: 3.5,R1: 3.1
60	Definitions & terminology discussion on green chemistry and fuels	CO 5	T1:4.2, R1:6.2.1
61	Definitions & terminology discussion on natural resources and environmental pollution	CO1, CO6	T4:2.1,2.8
DISCUSSION OF QUESTION BANK			
62	Question bank discussion on electrochemistry and Corrosion	CO 1, CO 2	T1: 6.1, R1:2.12
63	Question bank discussion on water technology	CO 3	T1:1.3, R1: 1.4
64	Question bank discussion on engineering materials	CO 4	T1: 3.5,R1: 3.1
65	Question bank discussion on green chemistry and fuels	CO5	T1:4.2, R1:6.2.1
66	Question bank discussion on natural resources and environmental Pollution	CO 6	T4:2.1,2.8

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

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

COURSE DESCRIPTION

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

I COURSE PRE-REQUISITES:

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

II COURSE OVERVIEW:

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

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

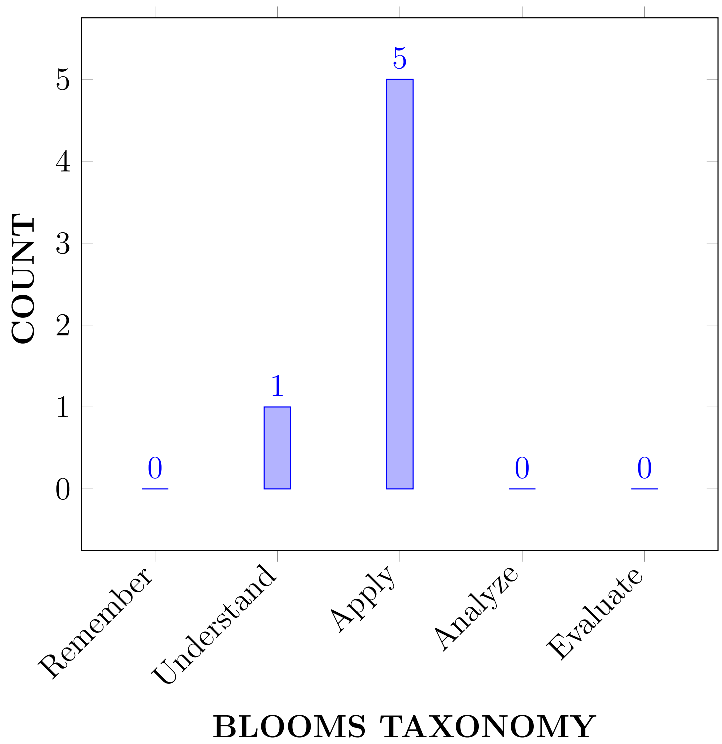
I	The transformation of ordinary differential equations in Laplace field and its applications
II	The operation of non-periodic functions by Fourier transforms.
III	The concepts of multiple integration for finding areas and volumes of physical quantities.
IV	The Integration of several functions by transforming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

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	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	**Explain** the properties of Laplace and inverse transform to to **complex engineering problems** of various functions such as continuous, piecewise continuous, step, impulsive and complex variable functions with **principle of mathematics** .	2
CO2	PO 2	**Describe** the **formulation of** integral transforms (knowledge) which converts **complex engineering problems** using (apply) operations of calculus to algebra along with **basic principles of mathematics** reaching substantiated conclusions by the **interpretation of results** in solving linear differential equations	6
	PO4	**Explain** the integral transforms in solving ordinary differential equations will be **quantitatively measured** by using **MATLAB computer software**.	5
	PSO1	**Describe** the integral transforms concern Aeronautical Engineering (apply) which converts operations of calculus to algebra in solving linear differential equations **in the design and implementation of complex systems.**.	2
CO3	PO 1	**Apply** the Fourier transform as a mathematical function that transforms a signal from the time domain to the **complex engineering problems** by the frequency domain, non-periodic function up to infinity with **Principle of Mathematics**	2
	PO2	**Apply** the Fourier transform as a **formulation** of mathematical function in **complex engineering problems** which transforms a non-periodic function using **principles of mathematics** to attain conclusions by the **interpretation of results**	6
	PSO1	**Identify** the properties of complex Fourier transform concern Aeronautical Engineering which **intensifies (apply)** the boundary value problems in the **design and implementation** of complex systems.	2
CO4	PO2	**Apply** the **formulation** of definite integral calculus to a function of **complex engineering problems** of two or more variables using **principle of mathematics** in calculating the area of solid bounded regions by the **interpretation of results**.	6
CO5	PO2	**Develop** the **statement** and **formulation** differential calculus of **complex engineering problems** which transforms vector functions, gradients. Divergence, curl, and integral theorems using **principle of mathematics** to different bounded regions in calculating areas. by **interpretation of results**	6

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

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback

XVIII SYLLABUS:

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

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

TEXTBOOKS

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

REFERENCE BOOKS:

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

WEB REFERENCES:

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

COURSE WEB PAGE:

XIX COURSE PLAN:

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

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

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

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

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

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

Signature of Course Coordinator **HOD,AE**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

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

I COURSE PRE-REQUISITES:

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

II COURSE OVERVIEW:

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

III MARKS DISTRIBUTION:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
16.7%	Remember
50%	Understand
33.3%	Apply
0 %	Analyze
0%	Evaluate

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

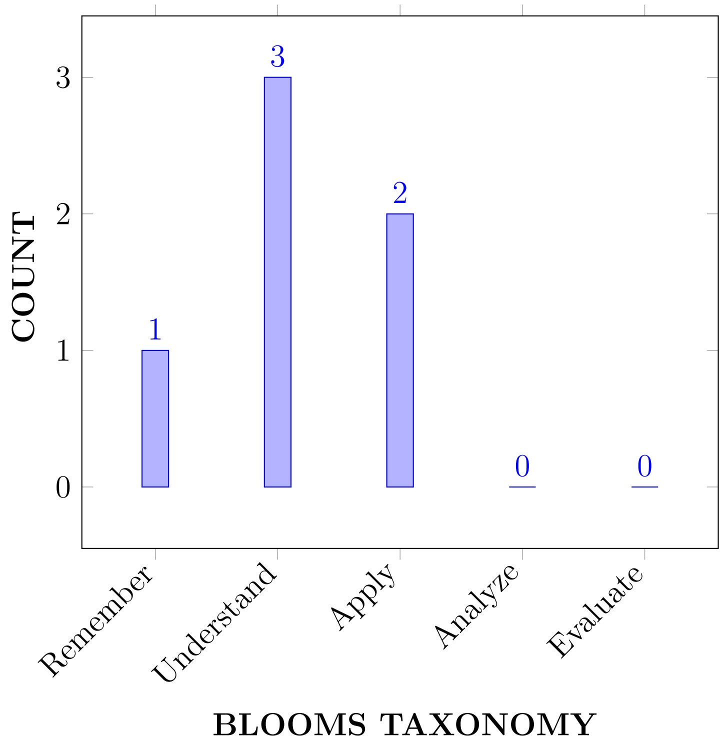
I	The fundamentals of electrical circuits and analysis of circuits with DC excitation using circuit laws.
II	The application of circuit laws in network theorems and graph theory to simplify complex networks.
III	The construction and working principle of DC generator, DC motor, andtypes of DC machines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

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

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

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

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

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

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

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 $<C \leq 40\%$ – Low/ Slight

2 - 40 % $<C < 60\%$ –Moderate

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

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

TEXTBOOKS

1. A Chakrabarti, "Electric Circuits", DhanipatRai and Sons, 6th Edition, 2010.
2. A Sudhakar, Shyammohan S Palli, "Circuits and Networks", Tata McGraw-Hill, 4th Edition, 2010.
3. V K Mehta, Rohit Mehta, —Principles of electrical engineering, S CHAND, 1st Edition, 2003.

4. A E Fitzgerald and C Kingsley, ”Electric Machinery”, McGraw Hill Education, 2013.
5. I J Nagrath, DP Kothari, “Electrical Machines”, Tata McGraw-Hill publication, 3rd Edition, 2010.

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/computer-science-engineering-autonomous/basic -electrical-engineering

XIX COURSE PLAN:

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

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

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

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

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

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

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

COURSE DESCRIPTION

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

I COURSE PRE-REQUISITES:

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

II COURSE OVERVIEW:

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

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Student's performance in the course shall be judged by taking into account the results of CIA and SEE together. Table-1 shows the typical distribution of weightage for CIA and SEE..

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

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

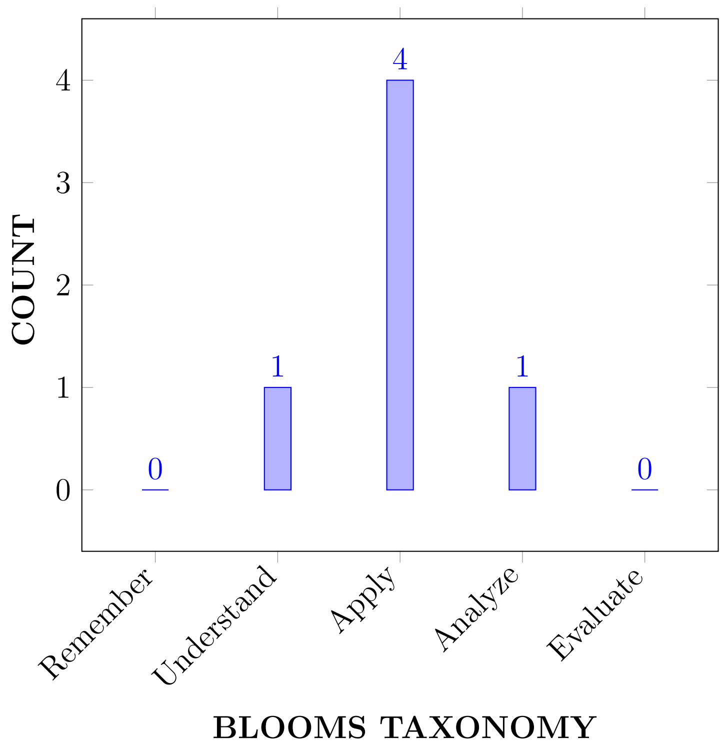
I	The application of mathematics and science principles to represent the free body diagrams in the area of rigid body mechanics.
II	The conditions of static and dynamic equilibrium of bodies subjected to a particular force system for solving the field problems.
III	The effects of force and motion while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

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	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.	3	CIE/Quiz/AAT
PO 2	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	1	[CIE/Quiz/AAT]
PO 4	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	1	Seminar/ Conferences / Research papers

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

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

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

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

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

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

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

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

TEXTBOOKS

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

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

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

REFERENCE BOOKS:

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

WEB REFERENCES:

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

COURSE WEB PAGE:

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

XIX COURSE PLAN:

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

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

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

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

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

Signature of Course Coordinator **HOD,ME**

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

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

I COURSE OVERVIEW:

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

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	ACSB02	II	-

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	The hands on experience in design, develop, implementation and evaluation by using Asymptotic notation.
II	The demonstration knowledge of basic abstract data types (ADT) and associated algorithms for organizing programs into modules using criteria that are based on the data structures of the program.

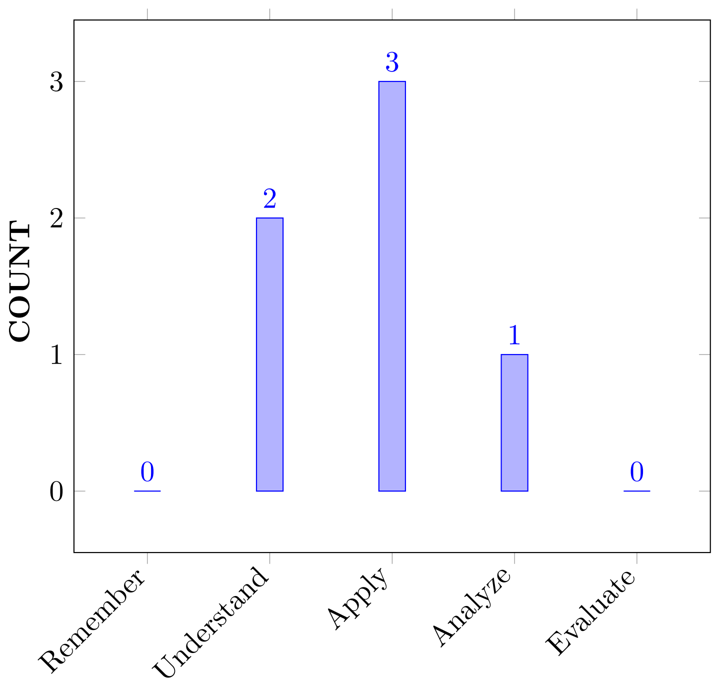
III	The practical implementation and usage of non linear data structures for solving problems of different domain.
IV	The knowledge of more sophisticated data structures to solve problems involving balanced binary search trees, AVL Trees, B-trees and B+ trees, hashing.
V	The graph traversals algorithms to solve real-world challenges such as finding shortest paths on huge maps and assembling genomes from millions of pieces

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



BLOOMS TAXONOMY

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	Design next-generation computer systems, networking devices, search engines, soft computing and intelligent systems, web browsers, and knowledge discovery tools. .	2	Viva-voce Laboratory Practices
PSO 2	Focus on mobile and web applications development and learn the emerging technologies and frameworks in demand with employers and contemporary challenges .	2	Viva-voce Laboratory Practices

PSO 3	Practical experience in shipping real world software, using industry standard tools and collaboration techniques will equip to secure and succeed in first job upon graduation in IT industry. .	2	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 Engineerig activities with an understanding of the limitations.	3
CO 2	PO 1	Understand (knowledge)the basic concept of algorithm analysis which provides theoretical estimates for the resources needed by any algorithm for a given computational problem. These estimates provide an insight into reasonable directions of search for efficient algorithms by applying the principles of **mathematics and science.**	3
	PO 5	Understand the (**knowledge**) appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	2
CO 3	PO 1	Understand (**knowledge**) the basic concept of algorithm analysis which provides theoretical estimates for the resources needed by any algorithm for a given computational problem. These estimates provide an insight into reasonable directions of search for efficient algorithms by applying the principles of **mathematics and science.**	3
	PO 5	Understand the (knowledge) appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	3
CO 4	PO 1	Describe (knowledge) the use sorting techniques as a basic building block in algorithm design and problem solving **using principles of mathematics, science, and engineering fundamentals.**	3
	PO 5	Understand the **knowledge** appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	2

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

	PO 3	Understand the applications of basic data structures such as stacks, queues, linked lists in (**designing and developing solutions of complex engineering applications.**	4
	PSO 1	Make use of modern computer tools for applying the basic data structure concepts in building real-time applications for a successful career.	
CO 9	PO 1	Apply the sophisticated hierarchical data structures to organize keys in form of a tree to use in many real-life applications by **using the principles of mathematics and engineering fundamentals.**	3
	PO 2	Make use of non-linear data structures such as balanced trees in by **identifying, formulating and analyzing complex engineering problems** such as databases, syntax tree in compilers and domain name servers etc. **with the help of basic mathematics and engineering sciences**.	3
	PO 3	Extend the concept of tree data structures to **design and develop solutions for complex engineering problems**.	3
	PSO 1	Make use of modern computer tools in implementing non-linear data structures for various applications to become a successful professional in the domain.	3
CO 10	PO 1	Demonstrate different tree structures in Python to implement real-time problems by **applying basic knowledge of science and engineering fundamentals.**	3
	PO 2	Illustrate the importance of tree data structures used for various applications **by identifying, formulating and analyzing complex engineering problems** such as operating systems and compiler design.	3
	PO 3	Make use of tree data structures to **design and develop solutions for complex engineering problems** and which is the key organizing factor in software design. Data structures can be used to organize the storage and retrieval of information stored in both main memory and secondary memory.	3
	PSO 1	Acquire sufficient knowledge in field of data structures and its applications by using modern computer tools so that new product development can take place, which leads to become successful entrepreneur and or to obtain higher education.	3
CO 11	PO 1	Understand (knowledge) the benefits of dynamic and static data structures implementations and choose appropriate data structure for specified problem domain **using knowledge of mathematics, science and engineering fundamentals.**	3
	PO 2	Recognize the need of dynamic and static data structures **in identifying, formulating and analyzing complex engineering problems.**	3

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

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

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

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

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

TEXTBOOKS

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

REFERENCE BOOKS:

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

XV COURSE PLAN:

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

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

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

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

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

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

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

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC04	I & II	-

II COURSE OVERVIEW:

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

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Engineering Workshop Practice 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 %	To test the preparedness for the experiment.	-
20 %	To test the performance in the laboratory.	-
20 %	To test the calculations and graphs related to the concern experiment.	-
20 %	To test the results and the error analysis of the experiment.	-
20 %	To test the subject knowledge through viva – voce.	-

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

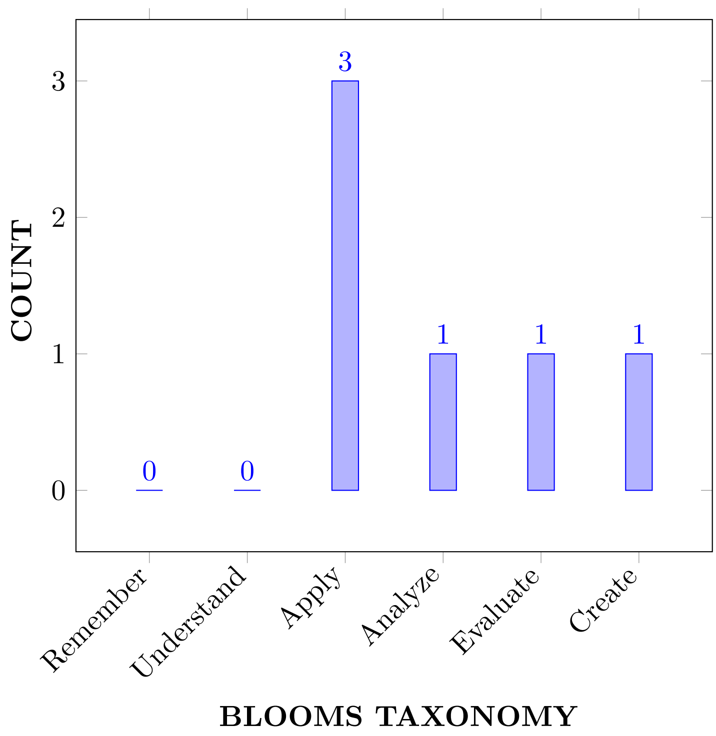
I	Use of common instruments including measuring, marking and cutting tools in various types of manufacturing processes.
II	Basic manufacturing concepts used in carpentry, fitting, black-smithy and tin-smithy.
III	Demonstrating skills by converting electrical circuit's diagrams into electrical wiring.
IV	Compare experimental results with diagrammatic measurements and to determine the source of any apparent differences.

VII COURSE OUTCOMES:

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

CO 1	**Identify** the ability to work from drawings and blueprints and demonstrate proficiency with hand tools common to carpentry.	Apply
CO 2	**Determine** the ability to Produce Fitting jobs as per specified dimensions in addition to demonstrating proficiency with hand tools common to fitting.	Evulate
CO 3	**Create** works of metal art using fire and furnace to convert given shape into useable elements using basic blacksmith techniques .	Create
CO 4	**Organisze** the moulding techniques for producing casting of different and complex shapes using various patterns.	Apply
CO 5	**Develop** various engineering and household articles such as tin boxes, cans, funnels, ducts etc., from a flat sheet of metal.	Apply
CO 6	**Compare** various wiring diagrams using conduit system of wiring and Prepare different types of wiring joints on the given circuit boards using appropriate electrical tools.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Experiments / 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 Experiments / CIE / SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations.	2	Lab Experiments / CIE / SEE
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	3	Lab Experiments / 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 Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies..	2	Lab Experiments / CIE / SEE

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	✓	-	✓	-	-	-	-	-	✓	-	-	-	✓
CO 2	✓	-	-	-	✓	-	-	-	-	-	✓	-	-	-	✓
CO 3	✓	-	-	-	✓	-	-	-	-	-	-	-	-	-	✓
CO 4	✓	-	✓		-	-	-	-	-	-	✓	-	-	-	-
CO 5	-	-	-	-	✓	-	-	-	-	-	✓	-	-	-	-
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 **engineering fundamentals** to join given wooden pieces according to given sketch to develop required joint..	1
	PO 3	Conversion of given design into a practical output using design solution for **complex engineering problems** and **design system components**.	2
	PO 5	Develop the given **resources and engineering tools** into proper fitment as given in the diagrammatical representation .	2
	PO 11	**Demonstrate** knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in **multidisciplinary environments.** .	2
	PS03	Make use of **Experimental tools** for Building Career Paths towards **Innovation Startups**, Employability in different mechanical trades.	2
CO 2	PO 1	the knowledge of **engineering fundamentals**to join given metal pieces according to given sketch to develop required joint.	1
	PO 5	Develop the given **resources and engineering tools** into proper fitment as given in the diagrammatical representation..	2
	PO 11	**Demonstrate** knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2
	PSO 3	Make use of **Experimental tools** for Building Career Paths towards **Innovation Startups**, Employability in different mechanical trades.	2
CO 3	PO 1	Apply the knowledge of **engineering fundamentals** to make metal rod into given required shape according to given sketch to develop required joint.	1
	PO5	Develop the given **resources and engineering tools**into required shape as given in the diagrammatical representation..	2
	PSO3	Make use of **Experimental tools** for Building Career Paths towards **Innovation Startups**, Employability in different mechanical trades..	2

Course Outcomes	**PO'S PSO'S**	**Justification for mapping (Students will be able to)**	**No. of Key Competencies matched.**
CO 4	PO 1	Apply the knowledge of **engineering fundamentals** to make the casting product from given materials according to given sketch to develop required shape..	1
	PO 3	Conversion of given design into a practical output using design solution for **complex engineering problems and design system components**.	2
	PO11	**Demonstrate** knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in **multidisciplinary environments.**.	2
CO 5	PO 5	Develop the given **resources and engineering tools** into required shape as given in the diagrammatical representation	2
	PO 11	**Demonstrate**knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in **multidisciplinary environments** .	2
CO 6	PO 1	Apply the knowledge of **engineering fundamentals** to make the required electrical connection according to given circuit diagram to develop connection..	1
	PO 5	Develop the given **resources and engineering tools** into proper fitment as given in the diagrammatical representation.	2
	PO 11	**Demonstrate** knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in **multidisciplinary environments.**	2
	PSO 3	Make use of **Experimental tools** for Building Career Paths towards Innovation Startups, Employability in different mechanical trades. .	2

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

XIII MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	**10**	**10**	**11**	**1**	**5**	**3**	**3**	**12**	**5**	**12**	**8**	**5**	**11**	**7**
CO 1	33.3	-	20	-	100	-	-	-	-	-	16.6	-	-	-	66.6
CO 2	33.3	-	-	-	100	-	-	-	-	-	-	-	-	-	66.6
CO 3	33.3	-	20	-	100	-	-	-	-	-	-	-	-	-	66.6
CO 4	33.3	-	20	-	100	-	-	-	-	-	16.6	-	-	-	-
CO 5	-	-	-	-	100	-	-	-	-	-	16.6	-	-	-	-
CO 6	33.3	-	-	-	100	-	-	-	-	-	16.6	-	-	-	66.6

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

0 - 0≤ 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	1	-	1	-	3	-	-	-	-	-	1	-	-		3
CO 2	1	-	-	-	3	-	-	-	-	-	-	-	-	-	3
CO 3	1	-	1	-	3	-	-	-	-	-	-	-	-	-	3
CO 4	1	-	1	-	3	-	-	-	-	-	1	-	-	-	-
CO 5	1	-	-	-	3	-	-	-	-	-	1	-	-	-	-
CO 6	1	-	-	-	3	-	-	-	-	-	1	-	-	-	3

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
TOTAL	**6**	**0**	**3**	**0**	**18**	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**0**	**0**	**12**
AVERAGE	**1**	**0**	**1**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**3**

XVI ASSESSMENT METHODOLOGY DIRECT:

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

XVII ASSESSMENT METHODOLOGY INDIRECT:

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

XVIII SYLLABUS:

WEEK-I	**CARPENTRY-I**
	Batch I: Preparation of Tenon joint as per given dimensions. Batch II: Preparation of Mortise joint as per given taper angle.
WEEK-II	**CARPENTRY-II**
	Batch I: Preparation of dove tail joint as per given taper angle. Batch II: Preparation of lap joint as per given dimensions.
WEEK-III	**FITTING - I**
	Batch I: Make a straight fit for given dimensions. Batch II: Make a square fit for given dimensions.
WEEK-IV	**FITTING - II**
	Batch I: Make a V fit for given dimensions. Batch II: Make a semicircular fit for given dimensions.
WEEK-V	**BLACKSMITHY- I**
	(Batch I: Prepare S-bend for given MS rod using open hearth furnace. Batch II: Prepare J-bend for given MS rod using open hearth furnace.
WEEK-VI	**BLACKSMITHY- II**
	Batch I: Prepare Fan hook for given dimensions. Batch II: Prepare Round to Square for given dimensions.
WEEK-VII	**MOULD PREPARATION-I.**
	Batch I: Prepare a wheel flange mould using a given wooden pattern. Batch II: Prepare a bearing housing using an aluminum pattern.
WEEK-VIII	**MOULD PREPARATION-II**

	Batch I: Prepare a bearing housing using an aluminum pattern. Batch II: Prepare a wheel flange mould using a given wooden pattern.
WEEK-IX	**TINSMITHY- I**
	Batch I: Prepare the development of a surface and make a rectangular tray for given dimensions. Batch II: Prepare the development of a surface and make a round tin for given dimensions.
WEEK-X	**TINSMITHY- II**
	Batch I: Prepare the development of a surface and make a Square Tin, for given dimensions. Batch II: Prepare the development of a surface and make a Conical Funnel for given dimensions.
WEEK-XI	**ELECTRICAL WIRING-I**
	Batch I: Make an electrical connection of two bulbs connected in series. Batch II: Make an electrical connection of two bulbs connected in parallel.
WEEK-XII	**ELECTRICAL WIRING-II**
	Batch I: Make an electrical connection of one bulb controlled by two switches connected. Batch II: Make an electrical connection of tube light.

REFERENCE BOOKS:

1. Gowri P. Hariharan, A. Suresh Babu," Manufacturing Technology – I", Pearson Education, 2018.
2. Roy A. Lindberg, "Processes and Materials of Manufacture", Prentice Hall India, 4th Edition, 2018.
3. Rao P.N., "Manufacturing Technology", Vol. I and Vol. II, Tata McGraw-Hill House, 2019.
4. Workshop technology by K.L.Narayana, 2020.

WEB REFERENCE BOOKS:

http://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
1	Tenon joint and Mortise joint.	CO 1	R1:11.1-11.5
2	Dove tail joint and Lap joint.	CO 2	R1:11.1-11.5
3	Straight fit and Square fit.	CO 3	R1:4.8 , R1:7.2
4	V fit and Semicircular fit.	CO 4	R1:4.8 , R1:7.2

5	S-bend and J-bend.	CO 3	R2:10.4 , R2:7.2
6	(a)Fan and Round to Square shape.	CO 4	R2:10.4 , R1:7.2
7	Wheel flange and bearing housing.	CO 4	R2:10.4 , R1:7.2
8	Bearing housing and Wheel flange .	CO 5	R1:8.2-8.5
9	(Rectangular tray and Round tin.	CO 5	R1:11.1-11.5
10	Make a Square Tin and Conical Funnel.	CO 5	R1:10.1 , R1:10.2
11	Series connection and parallel Connection.	CO 6	R1:11.1-11.5
12	One bulb controlled by two switches and tube light connection..	CO 6	R3:3.12 , R1:12.7

XX EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Connecting & Verifying Bell Circuit through House wiring trade.
2	Making of semitriangular fit using fitting trade.
3	Making of star shape using blacksmithy trade.
4	Preparation of hexognal tin using tinsmithy trade.
5	Preparation of dumbell shape using .

Course Coordinator **HOD,AE**
Mr. B.VijayaKrishna, 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**

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PSO1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	**3**
PSO2	Formulate and Evulate the concept of thermo fluid.	**3**
PSO3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	**3**

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

COURSE DESCRIPTION

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

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
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. The course includes: random variables, probability distributions, hypothesis testing, confidence intervals, and linear regression. There is an emphasis placed on real-world applications to engineering problems.

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

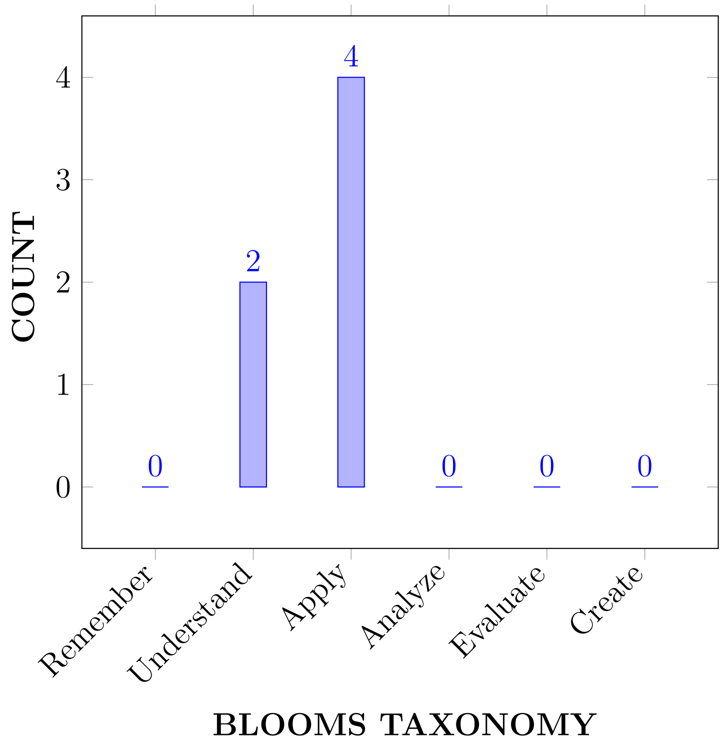
I	The theory of random variables, basic random variate distributions and their applications.
II	The Methods and techniques for quantifying the degree of closeness among two or more variables and the concept of linear regression analysis.
III	The Estimation statistics and Hypothesis testing which play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

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	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

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

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

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

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

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

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

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	-	-	45.5	-	-	-	-	-	-	-		-	-	-
CO 2	66.7	63.6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.7	-	-	45.5	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.7	63.6	-	45.5	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.7	-	-	45.5	100	-	-	-	-	-	-		-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - 40 % <C < 60% –Moderate
3 - 60% ≤ C < 100% – Substantial /High

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback

XVIII SYLLABUS:

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

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

TEXTBOOKS

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

WEB REFERENCES:

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

COURSE WEB PAGE:

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

REFERENCE BOOKS:

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

XIX COURSE PLAN:

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

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

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

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

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

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

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**MECHANICS OF SOLIDS**				
Course Code	AAEC01				
Program	B.Tech				
Semester	III	AE			
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	3	1.5
Course Coordinator	Mr S Devaraj, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	**Course Code**	**Semester**	**Prerequisites**
B.Tech	AMEC01	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). CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), and 10 marks for Alternative

Assessment Tool (AAT).

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

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
30%	Understand
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) and 10 marks for Alternative Assessment Tool (AAT).

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

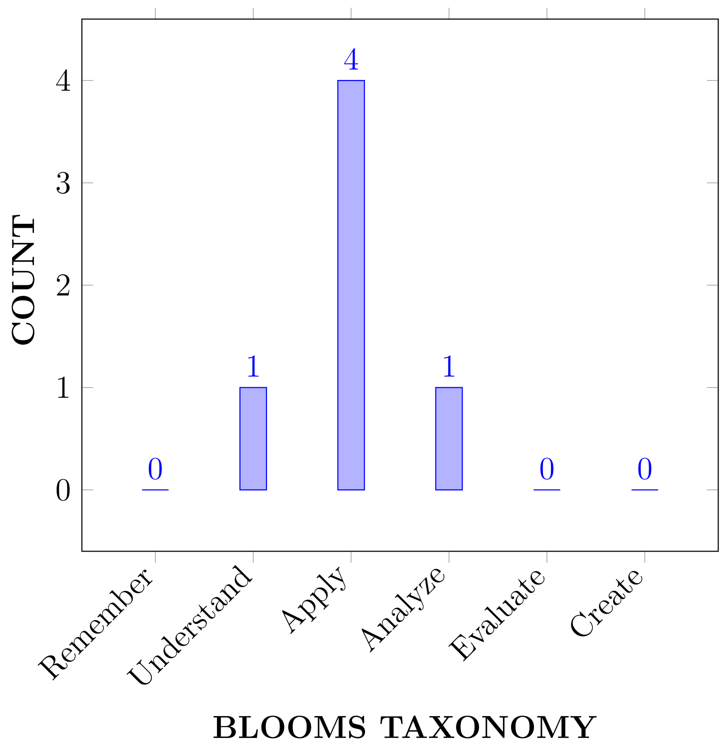
I	The concepts of mechanics of deformable solids and their constitutive relations (including stress – strain relations), principal stresses and strains and resilience produced under various loading conditions for determining the strength of aircraft structures.
II	The methods of determining shear force - 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 - $0 \leq$ 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	-	-	-	-	-	-	-	-	-	-	-	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	Reference T1: 4.1
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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**ENGINEERING THERMODYNAMICS**				
Course Code	AAEC02				
Program	B.Tech				
Semester	III				
Course Type	CORE				
Regulation	IARE - UG 20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3		
Course Coordinator	Ms. CH Ragha Leena				

I COURSE PRE-REQUISITES:

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

II COURSE OVERVIEW:

Engineering Thermodynamics is the field of physics which deals with the relationship between heat and mechanical work, and the properties of systems that bear relation to heat and work. General laws of energy transformations concerning all types of systems, mechanical, electrical and chemical may fall within the purview of this science. It is a science based on a number of empirical laws formed by experimentation from which all predictions concerning the physical behavior of the system may be deduced by logical reasoning. The findings have been formalized into certain basic laws, which are known as Zeroth law, First, Second and third laws of thermodynamics. Power cycles and refrigeration cycle based on thermodynamic system are analyzed for determination of their efficiencies and applications. This course emphasis on the groundwork for subsequent studies in the fields of fluid mechanics, heat transfer and to prepare the cohortsfor effective use of thermodynamics in the real-world applications.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Engineering Thermodynamics	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
50 %	Understand
50 %	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 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:

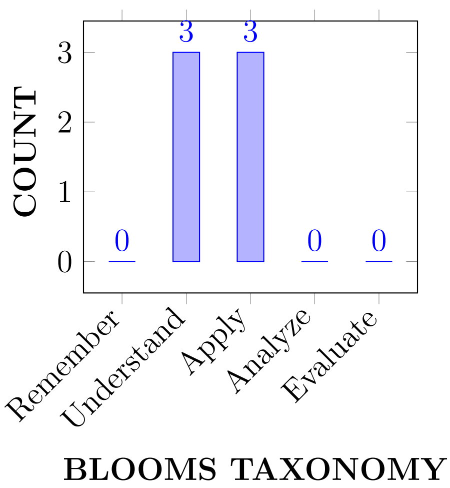
I	The concepts of thermodynamics, gas properties and the thermodynamic disorderness in the real time physical systems in heat engines, heat pumps and refrigerators for measure of their performance.
II	The characteristics of pure substances, mixtures, usage of steam tables, mollier' chart and psychometric charts for solving thermal problems.
III	The characteristics and performance of open and closed systems of thermodynamic cycles for effective delineation of real time applications.
IV	The methods of heat transfer and the suitability of heat exchangers and gas compressors in power plants and aircraft propulsion system.

VII COURSE OUTCOMES:

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

CO 1	**Interpret** the thermodynamic processes and energy conversions in physical systems based on fundamental laws of thermodynamics for identifying the significance of energy.	Understand
CO 2	**Make use of** heat to work conversion and thermodynamic direction laws involved in heat engines and heat pumps for deriving their efficiency and coefficient of performance.	Apply
CO 3	**Utilize** thermodynamic laws and entropy to describe the properties of pure substances and mixtures of perfect gases for examining the unavailability in any given system.	Apply
CO 4	**Choose** the properties of refrigernats and practicing of psychrometric charts for solving the complex problems of refrigeration and air conditioning.	Apply
CO 5	**Illustrate** the working principles of air standard cycles and its performance characteristics for recognizing the suitable engines in aeronautical and automobile applications.	Understand
CO 6	**Summarize** the basics of heat transfer, working principle of gas compressors and heat exchangers for relating their applications in aerospace engineering.	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	CIA/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	CIA/Quiz/AAT
PO 3	Design/development of solutions: Design solutions for complex engineering problems anddesign 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

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		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	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	**Demonstrate** the gas laws, principles of energy conversion systems in physical systems using **fundamental knowledge of science and engineering** to evolve relationships using partial derivative **mathematical functions**	3
	PO 2	Understand the working principles of energy conversions in physical systems by fundamental laws of thermodynamics **using the knowledge of engineering fundamentals and mathematics.**	5
	PSO 3	Establish the relationship between properties and functions applied to **thermal** systems and utilize such relations to solve **engineering problems** applied in **manufacturing** industry.	1
CO 2	PO 1	Using the law of conservation of energy, second law of thermodynamics and compare the Kelvin Planck and Clausius statements to evaluate the equivalence and similarity between them **using the fundamentals of engineering, science and mathematics.**	3
	PO 2	Recall the relationship between the various statements of second law of thermodynamics to develop different metaphysical system and interpret solutions for **engineering problems. Further, apply the basic engineering knowledge to derive futuristic solutions and solve engineering problems.**	5
	PSO 3	Understand the significance of law of conservation of energy and second law of thermodynamics applied to heat engines, heat pumps and refrigerators to solve (efficiencies) engineering **problems applied in manufacturing** industry.	2
CO 3	PO 1	**Illustrate** the properties of pure substances using **fundamental knowledge of science and engineering** to evolve relationships using partial derivative **mathematical functions**	3
	PO 2	**Understand the customer requirement, identify the cost** to correlate the properties of pure substances to emit relevant inlet and exit conditions of thermodynamic **work bearing systems used in various day to day applications**	5
	PO 3	**Investigate and define a problem** and identify constraints including environmental and **sustainability limitations, health and safety and risk assessment issues** when dealing with characteristics of pure substances in thermal processes and their **on real world problems**	7

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 3	Recall the properties of pure substances used in **thermal applications** to be applied in real life physical systems	2
CO 4	PO 1	Understand the significance of steam and gas tables psychrometry charts and Mollier diagram to determine the properties of refrigeration system **using the fundamentals of engineering and mathematical equations.**	3
	PO 2	**Model and validate** the steam and gas tables psychrometry charts and Mollier diagram in **real world applications to enumerate the various problems and effective solutions that can be proposed.**	7
	PO 3	Find **creative solution** for various problems related to refrigeration and air conditioning systems in adverse climatic conditions across the various tropics of the world. **Explore the problems** in current HVAC systems and find **avenues of innovations. Define problems** in integration of air-conditioning and HVAC systems to **find effective solutions.**	7
	PSO 3	Understand the significance steam and gas tables in **thermal problem related to multiple manufacturing systems in the current digital era**	2
CO 5	PO 1	Evaluate the performance characteristics of various air standard cycles using the **basic understanding of engineering science and mathematical equations.**	3
	PO 2	Using the fundamentals of air standard cycles **explore the possibilities** of combined cycles for **creating effective systems to be used in real world having better efficiencies.**	5
CO 6	PO 1	Understand the importance of modes of heat transfers, types of heat exchangers and gas compressors using the **fundamental engineering properties and mathematical equations.**	3
	PO 3	**Postulate problems** in heat transfers and heat exchangersto **create opportunities of improvement** in design and **development of superior systems in comparison to currently** available models.	7
	PSO 3	Apply the knowledge of heat exchanger concepts, gas compressors for various **thermal problems** found in the industry and find effective solutions.	1

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

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - $0 \leq C \leq 5\%$ – No correlation
1 -5 $< C \leq 40\%$ – 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	-	-	-	-	-	-	-	-	-	-	-	-	1
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 3	3	3	2	-	-	-	-	-	-	-	-	-	-	-	2
CO 4	3	3	3	-	-	-	-	-	-	-	-	-	-	-	2
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	-	3	-	-	-	-	-	-	-	-	-	-	-	1
TOTAL	18	12	8	-	-	-	-	-	-	-	-	-	-	-	8
AVERAGE	3	2.4	2.67	-	-	-	-	-	-	-	-	-	-	-	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	-	Tech Talk	✓	Projects	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**BASIC CONCEPTS AND FIRST LAW OF THERMODYNAMICS**
	Basic concepts: System, control volume, surrounding, boundaries, universe, types of systems, macroscopic and microscopic viewpoints, concept of continuum, thermodynamic equilibrium, state, property, process, cycle, reversibility, quasi static process, irreversible process, causes of irreversibility, various flow and non-flow processes, energy in state and in transition, types-work and heat, point and path function, Zeroth law of thermodynamics, concept of quality of temperature, Principles of thermometry, reference points, constant volume gas thermometer, ideal gas scale, PMMI Joule's experiments, first law of thermodynamics, corollaries first law applied to a process, applied to a flow system, steady flow energy equation.
MODULE II	**SECOND LAW OF THERMODYNAMICS**
	Limitations of the first law: thermal reservoir, heat engine, heat pump, parameters of performance, second Law of thermodynamics, Kelvin Planck and Clausius statements and their equivalence, Corollaries, PMM of second kind, Carnot's principle, Carnot cycle and its specialties, thermodynamic scale of temperature, Clausius inequality, Entropy, principle of Entropy increase, availability and irreversibility, thermodynamic potentials, Gibbs and Helmholtz functions, Maxwell relations, Third Law of thermodynamics.
MODULE III	**PURE SUBSTANCES AND MIXTURES OF PERFECT GASES**
	Pure substances: Phase transformations, T-S and H-S diagrams, P-V-T surfaces, triple point at critical state properties during change of phase, dryness fraction, Mollier charts, psychrometric properties, dry bulb temperature, wet bulb temperature, dew point temperature, thermodynamic wet bulb temperature, specific humidity, relative humidity, saturated air, vapour pressure, degree of saturation, adiabatic saturation, Carrier's equation, Psychrometric chart.
MODULE IV	**POWER CYCLES**
	Power cycles: Otto, Diesel, Dual combustion cycles, description and representation on P-V and T-S diagram, thermal efficiency, mean effective pressures on air standard basis, comparison of cycles, introduction to Brayton cycle and Bell Coleman cycle.

MODULE V	**ELEMENTS OF HEAT TRANSFER AND GAS COMPRESSORS**
	Basic concepts of Heat Transfer: Conduction, Convection and Radiation, Heat Exchangers, Types of Heat Exchangers. Basic concepts of: Gas Compressors, Air Compressors, Single-Stage Reciprocating Air Compressor, Multi-Stage Compression, Volumetric Efficiency, Air Motors, Rotary Compressors.

TEXTBOOKS

1. P. K. Nag, -Engineering Thermodynamics‖, Tata McGraw-Hill, 4th Edition, 2008.
2. YunusCengel, Michael A. Boles, Thermodynamics-An Engineering Approach, Tata McGraw-Hill, 7th Edition, 2011.
3. R.K.Rajput, "Engineering Thermodynamics", Laxmi Publications (P) Ltd, Third Edition, 2007.

REFERENCE BOOKS:

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

WEB REFERENCES:

1. https://en.wikipedia.org/wiki/Thermodynamics
2. https://en.wikipedia.org/wiki/Laws_of_thermodynamics
3. http://www.livescience.com/50776-thermodynamics.html
4. https://www3.nd.edu/ powers/ame.20231/planckdover.pdf

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	Basics concepts of Thermodynamics: Surrounding, Boundaries,Universe, Types of Systems, properties	CO 1	T1:1.1
3	Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic Equilibrium	CO 1	T1:1.5 R2:1.3

S.No	Topics to be covered	CO's	Reference T1: 4.1
4	State, Property, Process, Cycle, Reversibility, Quasi static Process, Irreversible Process, Causes of Irreversibility	CO 1	T1:1.6 R2: 1.39
5	Various flow and non-flow processes	CO 1	T1:1.7
6	Energy in State and in Transition, Types-Work and Heat, Point and Path function	CO 1	T1:1.8, R2: 1.63
7	Zeroth Law of Thermodynamics, Concept of quality of Temperature, Principles of Thermometry, Reference Points	CO 1	T1:2.1, R2: 1.72
8	Constant Volume gas Thermometer, Ideal Gas Scale, PMMI	CO 1	T1:2.3
9	Joule's Experiments, First law of Thermodynamics, CorollariesFirst law applied to a Process	CO 1	T1:2.4, R2: 2.13
10	Applied to a flow system, Steady Flow Energy Equation	CO 1	T1:2.5
11	Thermal Reservoir, Heat Engine, Heat pump, Parameters of performance	CO 2	T1: 6.3, R2: 2.19
12	Second Law of Thermodynamics, Kelvin Planck Statement	CO 2	T1:6.7
13	Clausius Statements and their Equivalence / Corollaries	CO 2	T1:6.5
14	PMM of Second kind, Carnot's principle	CO 2	T1:6.11
15	Carnot cycle and its specialties, Thermodynamic scale of Temperature, Clausius Inequality	CO 2	T1:7.6, R2: 2.23
16	Entropy, Principle of Entropy Increase, Availability and Irreversibility	CO 2	T1:8.8, R2: 2.26
17	Thermodynamic Potentials, Gibbs and Helmholtz Functions Maxwell Relations	CO 2	T1:11.2, R2:2.32
18	Elementary Treatment of the third Law of Thermodynamics	CO 2	T1:13.2
19	Pure Substances: Phase Transformations, T-S and H-S diagrams, P-V-T- Surfaces T-S And H-S diagrams, P-V-T-Surfaces	CO 3	T1:9.4, R2: 3.2
20	Triple Point At Critical State Properties During Change Of Phase	CO 3	T1: 10.11, R2: 3.31
21	Dryness Fraction, Mollier Charts, Problems	CO 3	T1: 11.2
22	Psychometric properties, psychrometric charts	CO 4	T1:15.2
23	Dry bulb temperature, wet bulb temperature, dew point temperature, thermodynamic wet bulb temperature	CO 4	T1:10.3
24	Dew point temperature, thermodynamic wet bulb temperature	CO 4	T1:10.3
25	Specific humidity, relative humidity, saturated air, vapour and pressure	CO 4	T1:10.5
26	Degree of saturation, adiabatic saturation, Carrier's equation	CO 4	T1:10.6
27	Otto combustion cycles description and representation on P-V and T-S diagram	CO 5	T1:15, R2:8
28	Diesel combustion cycles description and representation on P-V and T-S diagram	CO 5	T1:15, R2:8
29	Dual combustion cycles description and representation on P-V and T-S diagram	CO 5	T1:15, R2:8
30	Thermal efficiency, mean effective pressures on air standard basis, comparison of cycles	CO 5	T1:13.8, R2:8.15

S.No	Topics to be covered	CO's	Reference T1: 4.1
31	Thermal efficiency, mean effective pressures on air standard basis, comparison of cycles	CO 5	T1:13.8, R2:8.15
32	Introduction to Brayton cycle and Bell Coleman cycle.	CO 5	T1:13.9
33	Basic concepts of Heat Transfer: Conduction, Convection and radiation	CO 6	T1:18.1
34	Heat Exchangers, Types of Heat Exchangers	CO 6	T1:18.4
35	Basic concepts of Gas Compressors and Air Compressors	CO 6	T2: 16.4
36	Basic concepts of	CO 6	T2:17.2
37	Single-Stage Reciprocating Air Compressor	CO 6	T2:17-4
38	Multi-Stage Compression	CO 6	T2:17.9
39	Volumetric Efficiency, Air Motors	CO 6	T2: 17.13
40	Rotary Compressors	CO 6	T2 : 17.18
PROBLEM SOLVING/ CASE STUDIES			
1	Determine the work done, internal energy and heat transfer	CO 1	T1:1.5 R1:2.4
2	Determine the reference points steam point	CO 1	T1:1.5 R1:2.4
3	Determine the work done and heat transfer	CO 1	T1:1.5 R1:2.4
4	Problems on second law of thermodynamics, entropy concepts	CO 2	T1:1.5 R1:2.4
5	Determine the properties of solids and fluids at various conditions	CO 2	T1:1.5 R1:2.4
6	Compute the properties of different gases used in real applications	CO 3	T1:1.5 R1:2.4
7	Determine the humidity, relative humidity in refrigeration systems.	CO 4	T1:1.5 R1:2.4
8	Determine the process is reversible or irreversible	CO 2	T1:1.5 R1:2.4
9	Compute the efficiency of multi stage compressor	CO 6	T1:1.5 R1:2.4
10	Compute the efficiency of Diesel cycle from temperature	CO 6	T1:1.5 R1:2.4
11	Compute the mean pressure ration of Diesel cycle	CO 5	T1:1.5 R1:2.4
12	Problems on Specific humidity, relative humidity, saturated air, vapour pressure	CO 5	T1:1.5 R1:2.4
13	Problems on heat exchangers	CO 6	T1:1.5 R1:2.4
14	Problems on Single-Stage compression	CO 6	T1:1.5 R1:2.4
15	Problems on Elements of heat transfer and gas compressors	CO 6	T1:1.5 R1:2.4

S.No	Topics to be covered	CO's	Reference T1: 4.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	System, control volume, surrounding, boundaries, universe, types of systems, macroscopic and microscopic viewpoints, concept of continuum, thermodynamic equilibrium, state, property, process, cycle, reversibility, quasi static process, irreversible process	CO 1	T1:1.5 R1:2.4
2	Limitations of the first law: thermal reservoir, heat engine, heat pump, parameters of performance, second Law of thermodynamics, Kelvin Planck and Clausius statements and their equivalence, Corollaries, PMM of second kind, Carnot's principle, Carnot cycle and its specialties, thermodynamic scale of temperature	CO 2	T1:1.5 R1:2.4
3	Triple point, dry bulb temperature, wet bulb temperature, dew point temperature, thermodynamic wet bulb temperature, specific humidity, relative humidity	CO 3, CO 4	T1:1.5 R1:2.4
4	Otto, Diesel, Dual combustion cycles, description and representation on P-V and T-S diagram, thermal efficiency, mean effective pressures on air standard basis, comparison of cycles, introduction to Brayton cycle and Bell Coleman cycle.	CO 5	T1:1.5 R1:2.4
5	Conduction, Convection and Radiation, Heat Exchangers, Types of Heat Exchangers. Basic concepts of: Gas Compressors, Types of Air Compressors, Single-Stage compression, Multi-Stage Compression, Volumetric Efficiency, Rotary Compressors.	CO 6	T1:1.5 R1:2.4
DISCUSSION OF QUESTION BANK			
1	Quasi static process, Types-work and heat, first law of thermodynamics, PMMI Joule's experiments, first law applied to a flow system, steady flow energy equation.	CO 1	R2:2.1
2	second Law of thermodynamics, Kelvin Planck and Clausius statements and their equivalence, Entropy, principle of Entropy increase, availability and irreversibility, thermodynamic potentials	CO 2	T2:7.3
3	Phase transformations, T-S and H-S diagrams, P-V-T surfaces, triple point at critical state properties during change of phase, dryness fraction, Mollier charts, psychometric properties, dry bulb temperature, wet bulb temperature, dew point temperature, thermodynamic wet bulb temperature, specific humidity, relative humidity, saturated air, vapour pressure, degree of saturation, adiabatic saturation, Carrier's equation, Psychometric chart	CO 3, CO 4	R2:5.1

S.No	Topics to be covered	CO's	Reference T1: 4.1
4	Otto, Diesel, Dual combustion cycles, description and representation on P-V and T-S diagram, thermal efficiency, mean effective pressures on air standard basis, comparison of cycles, introduction to Brayton cycle and Bell Coleman cycle	CO 5	T1:7.5
5	Single-Stage compression, Multi-Stage Compression, Volumetric Efficiency, Rotary Compressors, Types of Heat Exchangers	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,AE**

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

COURSE DESCRIPTION

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

I COURSE PRE-REQUISITES:

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

II COURSE OVERVIEW:

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

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

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

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

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

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

is given in table.

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

VI COURSE OBJECTIVES:

The students will try to learn:

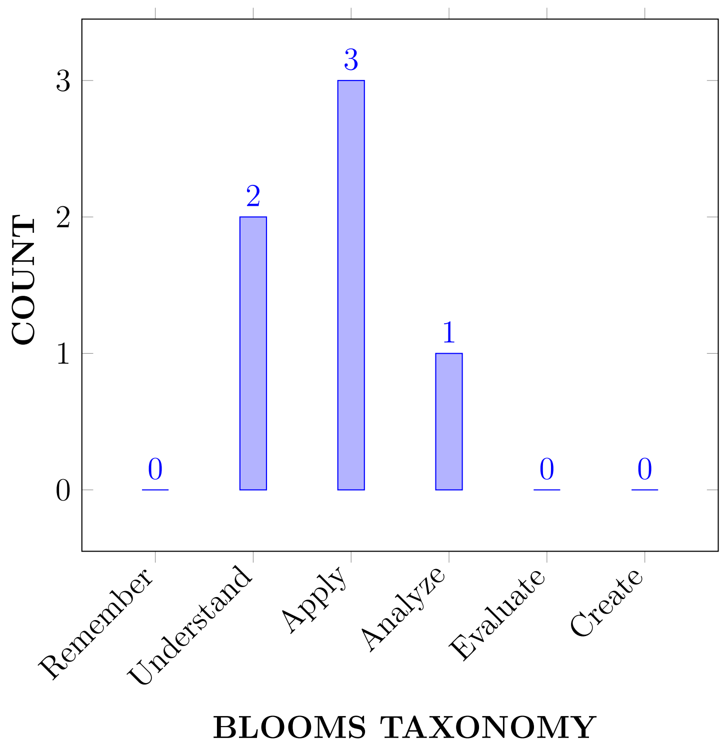
I	To provide students with skills needed to understand and analyze performance trade-offs of different algorithms / implementations and asymptotic analysis of their running time and memory usage.
II	To provide knowledge of basic abstract data types (ADT) and associated algorithms: stacks, queues, lists,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

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	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.	3	CIA/ SEE/ Tech Talk/ Concept Videos
PSO 2	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	2	CIA/ SEE/ Tech Talk/ Concept Videos
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	CIA/ SEE/ Tech Talk/ Concept Videos

3 = High; 2 = Medium; 1 = Low

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

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

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

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

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

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

CO 5	PO 1	**Understand** the knowledge of hashing techniques and collision resolution methods and implementing for specified problem domain using knowledge of mathematics, science and engineering fundamentals	1
	PO 3	**Design the Solution** for efficiently accessing data with respect to performance by using hashing techniques and collision resolution methods	2
	PO 5	**Implementation of** hashing techniques and collision resolution methods for efficiently accessing data with respect to performance with the help of computer software	1
	PO 10	**Subject matter and speaking style** assessed in explanation of Hashing, Collision techniques	2
	PSO1	**Understand** complex problems and analyzing it and apply appropriate hashing techniques and collision resolution methods for efficiently accessing data with respect to performance.	4
	PSO2	**Applying** various hashing techniques and collision resolution methods while designing and developing information retrieval systems and its applications	1
	PSO3	**Build** sufficient knowledge hashing techniques and collision resolution methods so that new product can be developed, which leads to become successful entrepreneur in the present market.	1
CO 6	PO 1	**Understand** various types of data structures in terms of implementations and choose appropriate data structure for specified problem domain using knowledge of mathematics, science and engineering fundamentals	3
	PO 2	**Problem Analysis:** Recognize the importance of suitable data structures in checking the efficiency of algorithms used for complex engineering problems.	7
	PO 3	**Design the Solution** complex problems or efficiently accessing data with respect to performance by using hashing techniques and collision resolution methods	5
	PO 4	**Conduct Investigations of Complex Problems:** Ability to apply operations on linear or nonlinear data structures in order to solve real time applications.	4
	PO 5	**Understand** the Implementation of various types of data structures with the help of computer software	1
	PO 10	**Subject matter and speaking** style assessed in explanation of Implementation of various types of data structures.	2
	PO 12	**Keeping current in CSE** and advanced engineering concepts of Implementation of various types of data structures by tech talk, concept videos and open ended experiments	3

	PSO 1	**Understand** complex problems and analyzing it and apply Implementation of various types of data structures.	5
	PSO 2	**Applying** Implementation of various types of data structures while designing and developing information retrieval systems and its applications	1
	PSO 3	**Build** sufficient knowledge Implementation of various types of data structures so that new product can be developed, which leads to become successful entrepreneur in the present market.	1

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

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	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	33.3	40	20	-	-	-	-	-	-	40	-	-	50	-	50
CO 2	33.3	50	20	-	100	-	-	-	-	40	-	25	66.6	100	50
CO 3	66.6	70	50	36.3	100	-	-	-	-	40	-	25	83.3	100	50
CO 4	100	70	20	36.3	100	-	-	-	-	40	-	-	66.6	50	50
CO 5	33.3	-	20	-	100	-	-	-	-	40	-	-	66.6	50	50
CO 6	100	70	50	36.3	100	-	-	-	-	40	-	25	83.3	50	50

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

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

XVI ASSESSMENT METHODOLOGY DIRECT:

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

XVII ASSESSMENT METHODOLOGY INDIRECT:

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

XVIII SYLLABUS:

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

TEXTBOOKS

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

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

REFERENCE BOOKS:

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

WEB REFERENCES:

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

COURSE WEB PAGE:

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

XIX COURSE PLAN:

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

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

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

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

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

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

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**FLUID DYNAMICS**				
Course Code	AAEC03				
Program	B.Tech				
Semester	III				
Course Type	Core				
Regulation	IARE - UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr V. Phaninder Reddy, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSC02	I	Linear Algebra and Calculus
B.Tech	AHSC07	II	Mathematical Transform Techniques
B.Tech	AMEC01	II	Engineering Mechanics

II COURSE OVERVIEW:

Fluid mechanics is the study of fluids either in motion (fluid dynamics) or at rest (fluid statics). This course introduces to a broad range of fundamental concepts, methods of fluid mechanics, mathematical description of fluid flows and the solution of some important flow problems. The course emphasizes importance of dimensionless numbers in various engineering fluid flow problems. It discusses the concept of boundary layer theory and bluff body aerodynamics. Compare and contrast various fluid machinery based on flow properties and its applications.

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
45%	Understand
45%	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 below table

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	The fundamental knowledge of fluids, their properties and behavior under various conditions of closed conduit and external flow systems.
II	Various mathematical models in fluid dynamics, how they are derived and how they can be used to solve practical problems.
III	The importance of formation of boundary layer when fluid flows over the solid bodies and effect in reduction of displacement, momentum, energy and pressure gradient.

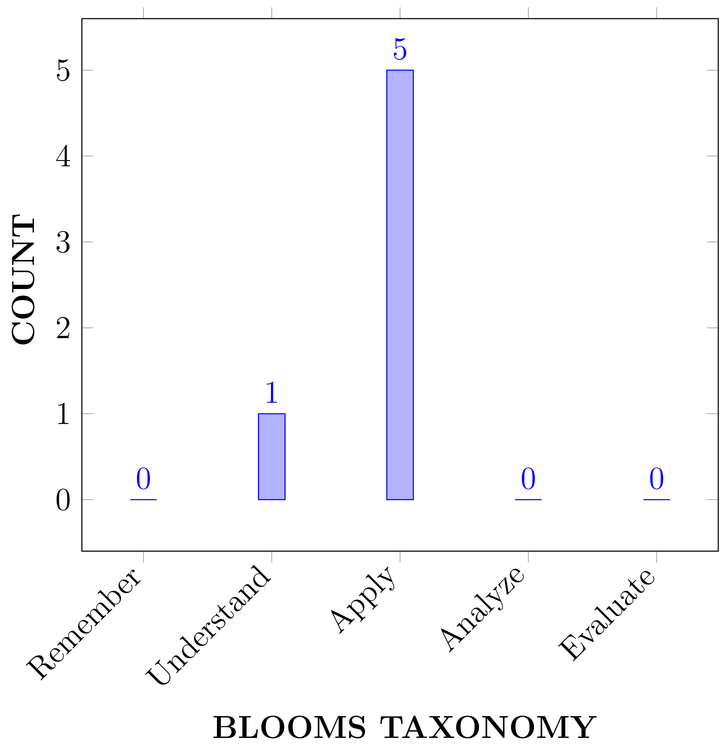
IV	Working principle of various turbo machineries, their application and analyze their characteristics using governing equations.

VII COURSE OUTCOMES:

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

CO 1	**Identify** the suitable pressure measuring devices for determining the flow measurements in fluid systems	Apply
CO 2	**Utilize** the concept of Similitude and Non Dimensional numbers for validating physical parameters of a designed prototype	Apply
CO 3	**Apply** the law of conservation of mass and momentum for obtaining numerical solutions of internal fluid flow systems	Apply
CO 4	**Utilize** the principle of Bernoulli equation for measurement of discharge in internal and external fluid flow systems	Apply
CO 5	**Apply** boundary layer theory for internal and external flow systems in determining drag forces and frictional losses.	Apply
CO 6	**Classify** the types of hydraulic machines based on working principle and performance characteristics for the selection in real world applications.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/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/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 SPECIFIC OUTCOMES		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	AAT
PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of fluid mechanics.	1	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	Understand the different types of pressure and pressure measuring devices and their applications by applying the principles of **mathematics, sciences and engineering fundamentals**.	3
	PO 2	Understand the given **problem statement** and **formulate** the metacentric height, centre of gravity and centre of pressure from the Hydrostatic law and Archimedes principle using first principles of **mathematics, natural sciences, and engineering sciences**	5
	PO 12	Recognize the types of fluid flows and pressure measuring devices that we use in daily life through the preparation and ability in personal development.	2
	PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of fluid mechanics.	2
CO 2	PO 1	Recognize the importance and application of dimensions, units and dimensional homogeneity in solving (complex) engineering problems with specific emphasis to thermal engineering by applying the **principles of mathematics, sciences and engineering fundamentals.**	3
	PO 2	**Collect the data** from complex **engineering problems** and implement them in determining the relation between models and prototype, **interpret** the results and **validate** the results obtained through model simulation.	5

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 2	Apply (knowledge) the concept of dimensional homogenity, dimensional analysis and similarity laws in solving themal engineering problems by applying the principles of **mathematics, science and engineering**	2
CO 3	PO 1	Apply the basic conservation laws of **science** for various phenomena of fluid systems and use **mathematical principles** for deriving (complex) fluid flow engineering equations by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals** of fluid mechanics.	3
	PO 2	Understand the given **problem statement** and **formulate** (complex) fluid flow engineering phenomena and system for deriving various governing equations of fluid mechanics from the **provided information** and substantiate with the **interpretation** of variations in the **results**	4
	PSO 2	Apply (knowledge) basic laws of conservation for various phenomena of fluid flow systems (understanding) with appropriate parametric assumptions and limitations (apply) in solving design problems by applying the principles of **mathematics, science and Engineering**	2
CO 4	PO 1	Recall(**Knowledge**) the concept of Euler equation of motion to a fluid element for determining Bernoulli equation of an incompressible fluid by applying the principles of **mathematics, science and Engineering**	3
	PO 2	Understand the given **problem statement** and **formulate** the discharge for a given flow measuring device from the **provided information** and substantiate with the **interpretation** of variations in the **results**	4
CO 5	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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	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, **analyse 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**	4
CO 6	PO 1	Explain (understanding) the theories, phenomena and working principles (knowledge) of hydraulic machines and their applicability (apply) in solving (complex) engineering problems related to hydraulic machines by applying the principles of fluid flow **engineering fundamentals** and their i**ntegration and support with other engineering disciplines, mathematics, science**	3
	PO 2	Understand the given **problem statement** and **formulate** the design (complex) engineering problems of hydraulic machines from the provided **information and data** in reaching substantiated conclusions by the **interpretation of results.**	4
	PO 4	**Recognize (knowledge)** the characteristics of various kinds of performance indicators and processes of hydraulic machines, understand the corresponding **context of the engineering knowledge** related to the performance indicators and measures, **technical uncertainty** of the unit and specific quantities causing the variations in the performance of hydraulic machines, **analyse key indicators** of performance by applying the model analysis by incorporating the **systems approach.**	5
	PSO 2	Apply (knowledge) the principal and performance characteristics (understanding) of hydraulic machines (apply) solving analysis problems by applying the principles of **mathematics, science and Engineering**	2

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	50	-	-	-	-	-	-	-	-	-	100	-	-	67
CO 2	100	50	50	-	-	-	-	-	-	-	-	-	-	67	-
CO 3	100	40	-	-	-	-	-	-	-	-	-	-	-	67	-
CO 4	100	40	-	-		-	-	-	-	-	-	-	-	-	-
CO 5	100	40	-	45	-	-	-	-	-	-	-	-	-	67	-
CO 6	100	70	50	45		-	-	-	-	-	-	-	-	67	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< 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% $\leq$ C < 100% – Substantial /High

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**FLUID PROPERTIES AND FLUID STATICS**
	Density, specific weight, specific gravity, surface tension and capillarity, Newton"s law of viscosity, incompressible and compressible fluid, numerical problems; Hydrostatic forces on submerged bodies - Pressure at a point, Pascal's law, pressure variation with temperature and height, center of pressure plane, vertical and inclined surfaces, Manometers - simple and differential Manometers, inverted manometers, micro manometers, pressure gauges and numerical problems. Buoyancy - Archimedes principle, metacenter, Meta centric height calculations; Stability
MODULE II	**DIMENSIONAL ANALYSIS**
	Fundamental and secondary quantities, Dimensional homogeneity, Methods of dimensional Analysis- Rayleigh's method, Buckingham's π- theorem, method of selecting repeating variables, similarity parameters - Reynolds number, Froude number, Euler's number, Weber's number, Mach number concepts of geometric, kinematic and dynamic similarity.
MODULE III	**KINEMATICS AND DYNAMICS OF FLUIDS**
	Methods of describing fluid motion, types of fluid flows, differential form of continuity equation- Cartesian, cylindrical and polar coordinate system, Numerical problems Euler's equation of Motion; Bernoulli's equation, Application of Bernoulli's equation in flow measurements: velocity and mass flow rate, pitot-static tube, venturi meter, orifice meter and V-Notch.
MODULE IV	**BOUNDARY LAYER THEORY**
	Introduction and classification of boundary layer, boundary layer properties- Displacement, momentum and energy thickness, idea of boundary layer separation, streamlined and bluff bodies, drag force on flat due to boundary layer
MODULE V	**TURBO MACHINERY**
	Introduction and classification of fluid machines: Turbo machinery analysis; The angular momentum principle; Euler turbo machine equation; Application to fluid systems, working principle overview of turbines, fans, pumps and compressors.

TEXTBOOKS

1. Frank M. White, "Fluid Mechanics ", McGraw Hill Education Private Limited, 8th Edition, 2017 .
2. R. K Bansal, "Fluid mechanics and hydraulic machines", Laxmi publications ltd, 9th Edition, 2011.

3. Robert W Fox, Alan T McDonald, "Introduction to fluid Mechanics", John Wiley and Sons, 6th Edition, 1995.

4. Yunus Cengel, John Cimbala, "Fluid Mechanics: Fundamentals and Applications",McGraw Hill Education Private Limited, 4th Edition 2014.

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1. Yuan S W, "Foundations of fluid Mechanics", Prentice-Hall, 2nd Edition, 1987.

2. Milne Thompson L M, "Theoretical Hydrodynamics", MacMillan, 5th Edition, 1968.

3. Rathakrishnan. E, "Fundamentals of Fluid Mechanics", Prentice-Hall, 5th Edition, 2007.

4. Som S. K, Biswas. G, "Introduction to fluid mechanics and fluid machines", Tata McGraw-Hill, 2nd Edition, 2004.

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	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
2	Fluid Dynamics Introduction, Fluid properties, Numerical properties	CO 1, 2	T2: 1.1-1.5, T1: 4.1
3	Newton's law of viscosity	CO 1	T2: 2.1-2.2, R1: 3.1
4	Incompressible and compressible fluid, numerical problems	CO 1	T2: 2.1-2.2, R1: 3.1
5	Buoyancy - Archimedes principle Hydrostatic forces on submerged bodies	CO 1	R4: 2.8
6	Pressure at a point, Pascal's law,	CO 1	T2: 2.3-2.4
7-8	Pressure variation with temperature and height, center of pressure plane, vertical and inclined surfaces	CO 1	R4: 2.7.1
9	Manometers - simple and differential Manometers numerical problems	CO 1	T2: 3.4
10	Inverted manometers, micro manometers, pressure gauges and numerical problems	CO 1	T2: 3.4
11	Metacenter, Meta centric height calculations; Stability	CO 1	T2: 3.3

S.No	Topics to be covered	CO's	Reference
12	Fundamental and secondary quantities, Dimensional homogeneity, Methods of dimensional Analysis	CO 2	T4: 7.1
13	Rayleigh's method, numerical problems Weber Number derivation	CO 2	R4: 6.3.3
14	Buckingham's π- theorem, method of selecting repeating variables	CO 2	R4: T6.3.2
15	Buckingham's π- theorem, Reynolds number and Froude Number derivation and their significance	CO 2	R4: T6.3.2
16	Buckingham's π- theorem, Mach Number, Prandtl Number Nussel number and their significance	CO 2	R4: T6.3.2
17	Similarity parameters: geometric, kinematic and dynamic similarity	CO 2	T1 5.5
18	Model Laws: dynamic similarity	CO 2	R4: 7.1
19	Methods of describing fluid motion:Lagragian and Eulerian approach	CO 4	T2: 5.1
20	Types of fluid flows and their mathematical formulation	CO 1	T2: 5.2
21	Differential form of continuity equation in Cartesian coordinate system	CO 3	R4: 4.2.1
22	Differential form of continuity equation in polar coordinate system	CO 3	R4: 4.2.2
23	Calculate Total, local and convective acceleration and velocity	CO 4	T1: 5.2
24	Euler's equation of Motion and Bernoulli's equation	CO 5	T1: 5.2
25	Determine velocity and mass flow rate of pitot-static tube, venturi meter, orifice meter Numerical problems	CO 4,5	T2: 5.2
26	Numerical problems of coefficient of discharge of venturi meter, orifice meter	CO 5	T2: 5.2
27	Flow through different notches and calculating Coefficent of discharge Numerical problems	CO 4,5	T2: 5.2
28	Introduction and classification of boundary layer	CO 5	T2: 13.1-13.2
29	Boundary layer properties- Displacement thickness	CO 5	T2: 13.1-13.2.5
30	momentum and energy thickness derivation	CO 5	T2: 13.2.6
30	Boundary layer Numerical Problems	CO 5	T2: 13.2.7
31	Streamlined and bluff bodies classification	CO 5	T4: 11.1-11.2
32	Drag force on flat plate due to boundary layer, Numerical problems	CO 5	T4: 11.2-11.4
33	Introduction and classification of fluid machines	CO 6	T1:11.1, T4:14.1
34	Working principle and classification of turbines.	CO 6	T1:11.1, T4:14.4
35	Working principle and classification of pumps and compressors.	CO 6	T1:11.2-11.4, T4:14.3
36	The angular momentum principle and Euler turbo machine equation derivation	CO 6	R4:15.3.1

S.No	Topics to be covered	CO's	Reference
37	Compare different turbines based on application and differentiate between turbine and pump.	CO 6	T1:11.1, T4:14.3-14.4
38	Turbo machinery analysis:Different efficiencies of turbine	CO 6	R4:15.4
39	Euler turbo machine equation application to fluid systems	CO 6	R4:15.3.1
40	Determine power required and efficiencies of turbine.	CO 6	T4:14.3-14.4
PROBLEM SOLVING/ CASE STUDIES			
1	Calculate fluid properties such as density, viscosity surface tension, kinematic visosity and specific weight.	CO 1	T2: 1.1-1.5, T1: 4.1
2	Calculate pressure head for different pressure meaasuring devices such as piezometer, U tube manometers and inverted U tube manometer	CO 1	T2: 3.4
3	Calculating center of pressure for the bodies submerged in fluid. Determine whether a floating body is stable by calculating metacentric height	CO 1	R4: 2.8
4	Dimensional Homogenity, determining non dimensional numbers using Rayleigh's method	CO 2	R4: T6.3.2
5	Estimating independent parameters by method of repeating variables and determining non dimensional numbers using Buckhingam pi theorem	CO 2	R4: T6.3.2
6	Calculate flow properties of model and prototype using geometric, kinematic and dynamic similarity	CO 2	R4: T6.3.2
7	Numerical problems relating to Bernoulli equation.	CO 5	R4:5.2
8	Finding coefficient of discharge using venturimeter(horizontal and inclined), orfice meter and V notch	CO 5	T2:5.2
9	Calculate velcity and acceleration by applying the concept of Eulerian and lagrangian approach	CO 4	T2: 5.2
10	Numerical problems relating to Boundary layer and boundary layer separation	CO 6	T2: 13.1-13.2.5
11	Calculate Coeffficient of lift and drag for different bluff bodies.	CO 6	T4: 11.2-11.4
12	Calculating Displacement, momentum and energy thickness	CO 6	T2: 13.2.6
13	Calculate performance characteristics of reciprocating and centrifugal pumps and compressors.	CO 6	T4:14.3-14.4
14	Numerical problems relating to Euler turbo machine equation	CO 6	T4:14.3-14.4
15	Calculate coeffficient of lift and drag for different bluff bodies.	CO 6	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Fluid properties, Archimedes Principle, Buoyancy, Centre of pressure, Pascal law, Condition for stability of a floating and submerged body	CO 1	T2: 1.1-1.5
2	Dimensions, Dimensional homogenity, Non dimensional numbers in thermal engineering, Similarity laws	CO 2	T4:7.3

S.No	Topics to be covered	CO's	Reference
3	Bernoulli theorem, Lagrangian and Eulerian approach, coefficient of discharge, Nappe, Notch and Weir, Types of fluid flows	CO 4,5	R4:5.1, T2: 6.3-6.4
4	Definition of boundary layer and separation, Bluff body and Streamlined body, Stokes law, Drag and lift	CO 5	T1:7.5
5	Kaplan, Francis and Pelton turbines, Centrifugal and Reciprocating pump, Euler turbine equation, characteristic curves of turbine	CO 6	T1: 12.1
DISCUSSION OF QUESTION BANK			
1	Problems relating fluid flow properties, pressure measuring devices and calculation of metacentre and metacentric height.	CO 1,2	T2: 1.1-1.5
2	For a given fluid flow problem determine whether it satisfy continuity equation, calculation of stream function and velocity potential. Clasiify different fluid flows	CO 3	R4: T6.3.2
3	Using bernoulli equation determine the discharge of flow measuring devices.	CO 4,5	R4:5.1
4	Calculate boundary layer thickness, displacement thickness and energy thickness. Calculation of drag and lift for streamlined and bluff bodies. Friction losses in Closed conduit flows.	CO 6	T4: 11.2-11.4
5	Calculation of efficiency of different hydraulic machines, velocity triangles.	CO 5	T1:11.2-11.4, T4:14.3

Signature of Course Coordinator **HOD,AE**
Mr. V Phaninder Reddy Assistant Professor

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

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**MECHANICS OF SOLIDS LABORATORY**				
Course Code	AAEC05				
Program	B.Tech				
Semester	III	AE			
Course Type	Core				
Regulation	IARE-UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Ms. Ch Ragha Leena, Assistant Professor				

I COURSE OVERVIEW:

Mechanics of solids laboratory enable the students to understand the basic concepts of Mechanics of Solids and apply them to practical problems in Aerospace applications. Mechanical tests are conducted as per standards (ASTM and IS) for identifying the properties of various materials such as Young's Modulus, Hardness, Toughness, stiffness subjected to various loading and support conditions.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME002	II	Engineering Mechanics

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Mechanics of solids Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for b internal 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:

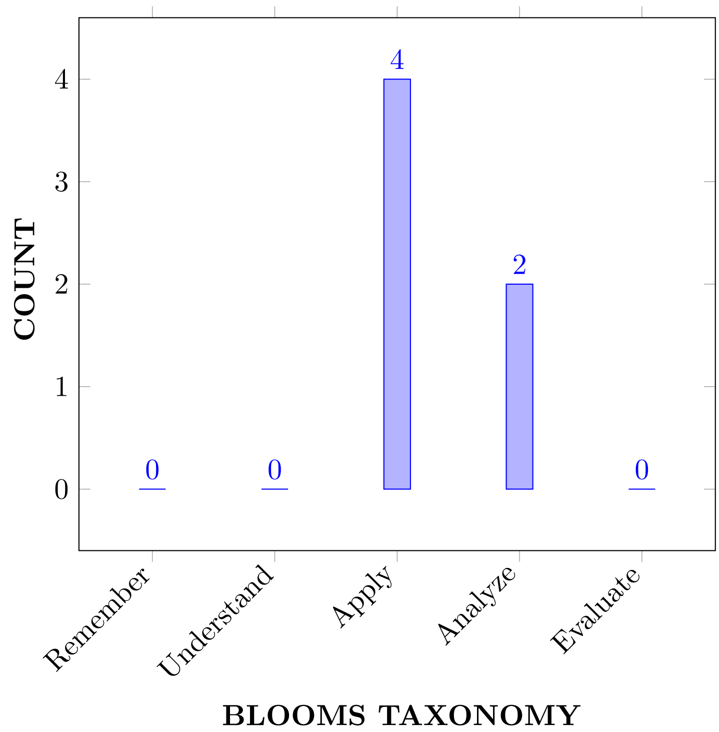
I	Learn the basic knowledge on the mechanical behaviour of materials like aluminium, mild steel, and cast iron.
II	Adopt with the experimental methods to determine the mechanical properties of materials.
III	Illustrate the crippling behaviour of different columns using Euler's and Rankine's theory.
IV	Determine the elastic constants of different materials by conducting experiments.

VII COURSE OUTCOMES:

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

CO 1	**Examine** the Hardness of mild steel, carbon steel, brass and aluminium specimens using Brinell's and Rockwell's hardness test for characterization of materials used in engineering applications.	Analyze
CO 2	**Make use of** stress and strains relations of mild steel materials for observing ultimate load using Universal testing machine for design of machine components.	Apply
CO 3	**Identify** the modulus of rigidity of a given shaft and spring wire for designing aerospace and automobile structures under loading conditions.	Apply
CO 4	**Analyze** the impact strength of steel using Izod and Charpy test for characterization under suddenly applied load.	Analyze
CO 5	**Identify** the buckling load and crushing load of long and short columns for designing structures subjected to different loads and boundary conditions.	Apply
CO 6	**Choose** the deflection equation of simply supported and cantilever beam for determining the young's modulus to predict the behaviour of the beam.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises
PO 2	**Problem analysis:** 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
PO 6	**The Engineer and Society:**Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	Lab Exercises
PO 9	**Individual and Teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings .	3	Lab Exercises
PO 10	**Communication:** Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions .	2	Lab Exercises

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	Apply the basics **engieering science and principles of mathematics** to analyze the different materials by using hardness tests.	2

	PO 2	Analyze different materials to design structural components by using structural analysis concepts **formulate** and **state a problem,** and **develop solution** and **document the results.**	5
	PO 6	Understand the commercial and economic context of engineering processes to **assess societal, health, safety and the consequent responsibilities** relevant to the professional engineering practice	1
	PO 9	Understand the complex problems either by **individual or team work** to obtain the appropriate results.	8
	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments.	2
	PSO 2	**Identify** the characteristics of different materials used in engineering structures to design the structural components.	2
CO 2	PO 1	Recall (knowledge) the different structures subjected to tensile load 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.**	5
	PO 6	Understand the commercial and economic context of engineering processes to **assess societal, health, safety and the consequent responsibilities** relevant to the professional engineering practice	1
	PO 9	Understand the complex problems either by **individual or team work** to obtain the appropriate results.	8
	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments.	2
	PSO 2	Select the appropriate method for the analysis of structures using **Safety** and **serviceability of structure** 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 and wire to calculate the modulus of rigidity under loading using the structural analysis concepts, **formulate** and **state a problem,** and **develop solution** and **document the results.**	5
	PO 6	Understand the commercial and economic context of engineering processes to **assess societal, health, safety and the consequent responsibilities** relevant to the professional engineering practice	1
	PO 9	Understand the complex problems either by **individual or team work** to obtain the appropriate results.	8

	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments.	2
	PSO 2	Understand the design of shafts based on Indian standards using **Performance improvement** and **Safety and serviceability** of shaft.	2
CO 4	PO 1	Understand the different components in the engineering structures 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.**	5
	PO 6	Understand the commercial and economic context of engineering processes to **assess societal, health, safety and the consequent responsibilities** relevant to the professional engineering practice	1
	PO 9	Understand the complex problems either by **individual or team work** to obtain the appropriate results.	8
	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments.	2
	PSO 2	Understand the design of structures based on Indian standards using **Performance improvement** and **Safety and serviceability** .	2
CO 5	PO 1	Understand the basic concepts of columns for determining the buckling and crushing loads **using mathematics and engineering fundamentals.**	2
	PO 2	Analyze the columns under 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.**	5
	PO 6	Understand the commercial and economic context of engineering processes to **assess societal, health, safety and the consequent responsibilities** relevant to the professional engineering practice	1
	PO 9	Understand the complex problems either by **individual or team work** to obtain the appropriate results.	8
	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments.	2
	PSO 2	Understand the design of columns based on Indian standards using **Performance improvement** and **Safety and serviceability** of shaft.	2
CO 6	PO 1	Understand the different components in the engineering structures 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.**	5
	PO 6	Understand the commercial and economic context of engineering processes to **assess societal, health, safety and the consequent responsibilities** relevant to the professional engineering practice	1
	PO 9	Understand the complex problems either by **individual or team work** to obtain the appropriate results.	8
	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments.	2
	PSO 2	Understand the design of beams based on Indian standards using **Performance improvement** and **Safety and serviceability** .	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	PO6	PO9	PO 10	PSO 2
CO 1	3	2	1	3	2	1
CO 2	3	2	1	3	2	1
CO 3	3	2	1	3	2	1
CO 4	3	2	1	3	2	1
CO 5	3	2	1	3	2	1
CO 6	3	2	1	3	2	1

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**BRINELL HARDNESS TEST**
	Determination of Brinell number of a given test specimen.
WEEK II	**ROCKWELL HARDNESS TEST**

	Determination of hardness number of different specimens such as steel, brass, copper and aluminum.
WEEK III	**TENSION TEST**
	Study the behavior of mild steel and various materials under different loads. To determine a) Tensile b) Yield strength c) Elongation d) Young‘s modulus
WEEK IV	**TORSION TEST**
	Determine of Modulus of rigidity of various specimens.
WEEK V	**IZOD IMPACT TEST**
	Determination the toughness of the materials like steel, copper, brass and other alloys using Izod test
WEEK VI	**CHARPY IMPACT TEST**
	Determine the toughness of the materials like steel, copper, brass and other alloys using Charpy test.
WEEK VII	**COMPRESSION TEST ON SHORT COLUMN**
	Determine the compressive stress on material.
WEEK VIII	**COMPRESSION TEST ON LONG COLUMN**
	Determine Young‘s modulus of the given long column.
WEEK IX	**TESTING OF SPRINGS**
	Determine the stiffness of the spring and the Modulus of rigidity of wire material.
WEEK X	**DEFLECTION TEST FOR SIMPLE SUPPORTED BEAM**
	Determine the Young‘s modulus of the given material with the help of deflection of Simple Supported Beam.
WEEK XI	**DEFLECTION TEST FOR CANTILEVER BEAM**
	Determine the Young‘s modulus of the given material with the help of deflection of Cantilever beam.
WEEK XII	**REVIEW - II**
	Spare session for additional repetitions and review.

REFERENCE BOOKS:

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.

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 Brinell number of a given test specimen.	CO 1	R2:2.3
2	Determination of hardness number of different specimens such as steel, brass, copper and aluminum.	CO 1	R1:2.6
3	Study the behavior of mild steel and various materials under different loads. To determine a) Tensile b) Yield strength c) Elongation d) Young‘s modulus	CO 2	R1:2.6

4	Determine of Modulus of rigidity of various specimens.	CO 3	R1:2.18
5	Determination the toughness of the materials like steel, copper, brass and other alloys using Izod test.	CO 4	R3:2.22
6	Determine the toughness of the materials like steel, copper, brass and other alloys using Charpy test.	CO 4	R2:2.25
7	Determine the compressive stress on material.	CO 5	R1:2.55
8	Determine Young's modulus of the given long column.	CO 5	R2:2.3
9	Determine the stiffness of the spring and the Modulus of rigidity of wire material.	CO 3	R1:2.6
10	Determine the Young's modulus of the given material with the help of deflection of Simple Supported Beam.	CO 6	R1:2.6
11	Determine the Young's modulus of the given material with the help of deflection of Cantilever beam.	CO 6	R1:7.2
12	Spare session for additional repetitions and review.	CO 1- CO 6	R1:7.2

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

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

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**FLUID DYNAMICS LABORATORY**				
Course Code	AAEC05				
Program	B.Tech				
Semester	III				
Course Type	Laboratory				
Regulation	UG-20				
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	AAEC03	III	Fluid Dynamics

II COURSE OVERVIEW:

The Fluid Dynamics 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.

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	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	DATA STRUCTURES LABORATORY				
Course Code	ACSC10				
Program	B.Tech				
Semester	III	AE			
Course Type	Core				
Regulation	IARE - UG 20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Dr. Sitharamulu, Assistant Professor				

I COURSE OVERVIEW:

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

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	ACSC02	I	Python Programming Laboratory
B.Tech	ACSC08	III	Data Structures

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	To provide students with skills needed to understand and analyze performance trade-offs of different algorithms / implementations and asymptotic analysis of their running time and memory usage.

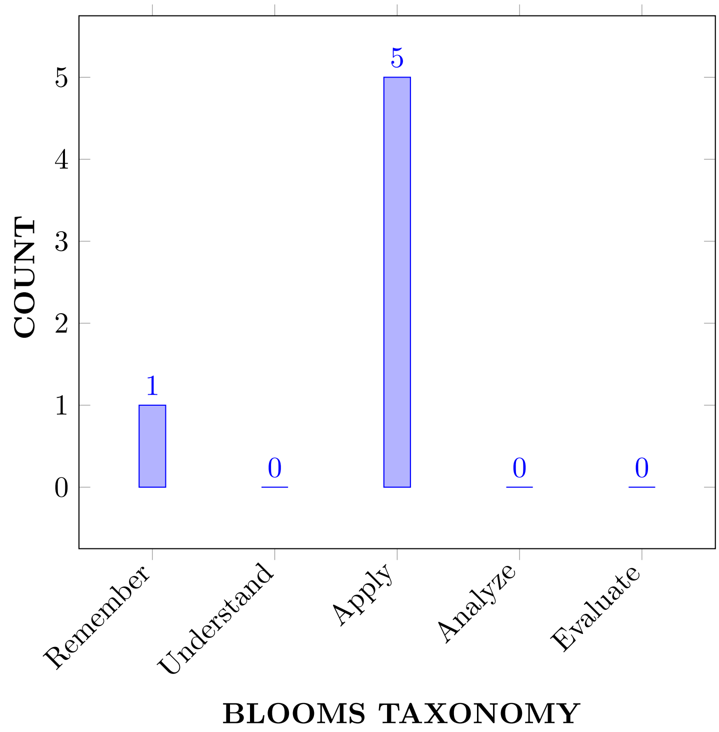
II	To provide knowledge of basic abstract data types (ADT) and associated algorithms: stacks, queues, lists, tree, graphs, hashing and sorting, selection and searching. .
III	The fundamentals of how to store, retrieve, and process data efficiently.
IV	To provide practice by specifying and implementing these data structures and algorithms in Python.
V	Understand essential for future programming and software engineering courses.

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises
PO 2	**Problem Analysis:** Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences	3	Lab Exercises
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	Lab Exercises
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions	2	Lab Exercises
PO 5	**Modern Tool Usage:**Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1	Lab Exercises
PO 6	**The Engineer and Society** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice	2	Lab Exercises
PO 8	**Ethics** Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice	3	Lab Exercises
PO 9	**Individual and Teamwork** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	3	Lab Exercises
PO 10	**Communication:** Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	4	Lab Exercises

PO 12	**Life - Long Learning:**Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Identify appropriate searching technique for efficient retrieval of data stored location by applying the **principles of Mathematics and Engineering** , **Scientific principles and methodology**,**engineering disciplines to integrate / support study**	3
	PO 2	Identify appropriate searching technique for efficient retrieval of data stored location by applying Problem Analysis **Problem statement and system definition**,**Information and data collection**,**Solution development or experimentation / Implementation**	3
	PO 3	**Identify** appropriate searching technique for efficient retrieval of data stored location by applying **Design/Development of Solutions**	3
	PO 4	Identify**apply**appropriate searching technique for efficient retrieval of data stored location by applying **Conduct Investigations of Complex Problems**	2

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

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

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

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

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

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

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

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

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

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

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

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

TEXTBOOKS

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

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

REFERENCE BOOKS:

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

2. Yashavant Kanetkar, Aditya Kanetkar, —Let us Python‖, BPB publication, 1st Edition, 2019.

3. Ashok Kamthane, Amit Kamthane, —Programming and Problem Solving with Python‖, McGraw Hill Education (India) Private Limited, 2018.

4. Taneja Sheetal, Kumar Naveen, —Python Programming – A modular approach‖, Pearson, 2017.

5. R Nageswara Rao, —Core Python Programming‖, Dreamtech Press, 2017 Edition.

WEB REFERENCES:

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

2. https://python.swaroopch.com/oop.html

3. https://python-textbok.readthedocs.io/en/1.0/Object-Oriented-Programming.html

4. https://www.programiz.com/python-programming/

5. . https://www.geeksforgeeks.org/python-programming-language

XV COURSE PLAN:

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

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

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

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

5	**Flow through pipes:** There is a garage where the access road can accommodate any number of trucks at one time. The garage is building such a way that only the last truck entered can be moved out. Each of the trucks is identified by a positive integer (a truck-id). Write a program to handle truck moves, allowing for the following commands: a) On-road (truck-id); b) Enter-garage (truck- id); c) Exit-garage (truck-id); d) Show-trucks (garage or road); If an attempt is made to get out a truck which is not the closest to the garage entry, the error message Truck x not near garage door

Signature of Course Coordinator **HOD,IT**
Mrs. K LAXMINARAYANAMMA, Assistant Professor

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

COURSE DESCRIPTION

Course Title	**AERODYNAMICS**				
Course Code	AAEC08				
Program	B.Tech				
Semester	IV	AE			
Course Type	Core				
Regulation	UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. Maruthupandiyan K, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEC03	III	FLUID DYNAMICS

II COURSE OVERVIEW:

Aerodynamics course focuses on the study of the flow of air about a body, and the body can be an airplane, but many of the concepts explored are relevant to a wide variety of applications from sailboats, automobiles and 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.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Aerodynamics	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
20%	Remember
40%	Understand
40%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) 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 below table

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	The fundamental knowledge on 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.

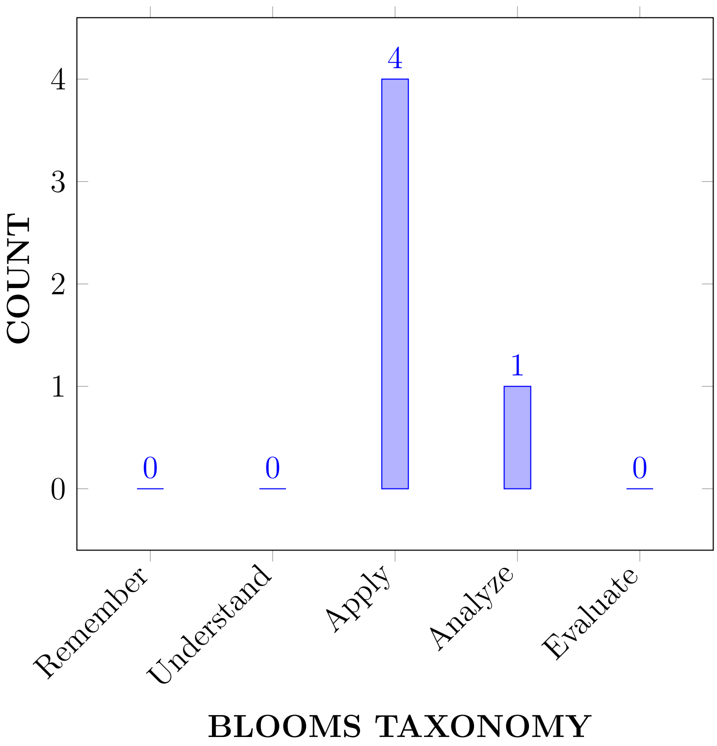
III	The flow over non-lifting bodies from method of singularities and Joukowski transformation
IV	The effect of viscosity and boundary layer growth over various shaped geometry and its control.

VII COURSE OUTCOMES:

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

CO 1	**Develop** the mathematical model of non-lifting, lifting flow over circular cylinder for identifying relation between lift and circulation	Apply
CO 2	**Solve** the lift characteristics of wing of infinite aspect ratio from classical thin airfoil for selecting suitable airfoil	Apply
CO 3	**Examine** the flow over finite wing using the concept of Prandtl's lifting line theory for determining the effect of span wise flow on the lift distribution.	Analyze
CO 4	**Identify** the effect of wing twist, wing taper and wing sweep for perceiving the aerodynamic characteristics of finite wing.	Apply
CO 5	**Make use of** the Kutta-Joukowski transformation for mathematically modeling the flow over airfoil..	Apply
CO 6	**Distinguish** the regimes and separation of boundary layer over external fluid flow systems for finding the effect of viscosity on the drag force	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

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	AAT

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Explain (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
	PO 2	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 1	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 2	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 by applying the principles of**mathematics, science and Engineering**	4
	PSO 21	Apply (knowledge) concept of thin airfoil theoryfor 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 3	PO 1	Analyze the flow over finie wing by applying 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

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** 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**.	3
	PSO 1	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 4	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
	PSO 1	Apply (knowledge Prandtl's lifting line theory for wing of finite aspect ratio (understanding) with appropriate parametric assumptions and limitations (apply) in solving design problems by applying the principles of **mathematics, science and Engineering.**	3
CO 5	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 principles of **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
	PSO 1	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 6	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	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 1	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

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-		3	-	-
CO 3	3	2		-	-	-	-	-	-	-	-	-	3	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-		3	-	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
TOTAL	18	10	-	-	-		-	-	-	-	-	-	18	-	-
AVERAGE	3	1.67	-	-	-		-	-	-	-	-	-	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	**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, CL-/alpha- diagram for a wing of infinite aspect ratio, generation of lift, starting Vortex, Kutta's trailing edge condition; Thin aerofoil theory; 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 CONFORMAL TRANSFORMATION**
	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. Potential, Cauchy-Reiman relations, Complex conformal transformation, Kutta-Joukowski transformation
MODULE V	**BOUNDARY LAYER THEORY**
	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

TEXTBOOKS

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", McGraw 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.

COURSE WEB PAGE:

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1			
CONTENT DELIVERY (THEORY)			
2	Potential flow	CO1	T2: T2:104-105
3	Velocity potential,Stream function	CO 1	T2:105-110
4	Laplace equation,Flow singularities	CO 1	T2:104-105 R1:3.2

5	Uniform flow,Source, Sink,	CO 1	T2:119-130 R1:3.4
6	Doublet, Vortex,	CO 1	T2:119-130 R1:3.3
7	Non lifting and lifting flow over a cylinder	CO 1	T2:119-130 R1:3.5
8	Kutta-Joukowski theorem	CO 1	T2:119-130 R1:3.6
9	Aerofoil nomenclature	CO 2	T2:131-132 R1:3.7
10	Aerodynamic characteristics,Centre of pressure,Aerodynamic centre	CO 2	T2:167 R1:3.7
11	Wing of infinite aspect ratio	CO 2	T2: 192 R2:8.1
12	CL-α - diagram for a wing of infinite aspect ratio	CO 2	T1:4.3 R2:8.1
13	Generation of lift,Starting Vortex,Kutta's trailing edge condition	CO 2	T1:1.6-4.9
14	Thin aerofoil theory	CO 2	T1:4.7
15	Elements of panel method	CO 2	T1:4.7
16	High lift airfoils, High lift devices	CO 2	T1:4.5
17	Vortex motions, Vortex line, Vortex tube,Vortex sheet	CO 4	T1:4.7-4.10 R2:8.3
18	Circulation,	CO 4	T1:4.10
19	Biot-Savart's law applications, Rankine's vortex	CO 4	T1:4.12
20	Flow past finite wings, Vortex model of the wing and bound vortices	CO 4	T1:5.2 R2:11.1
21	Induced drag	CO 4	T1:5.2 R2:11.1
22	Prandtl's lifting line theory	CO 4	T1:4.6
23	Elliptic wing, Influence of taper and twist applied to wings	CO 4	T1:4.6
24	Effect of sweep back wings, Delta wings	CO 4	T1:5.2
25	Primary and secondary vortex, Elements of lifting surface theory	CO 4	T1:5.3
26	Source Panel Vortex panel, Vortex lattice methods	CO 4	T1:5.2 R2:10.1
27	Flow past non lifting bodies,Method of singularities	CO 5	T1:5.3 R2:11.3

28	Flow over airplane as a whole, Wing-body interference	CO 5	T1:5.3 R2:11.3
29	Effect of propeller on wings and bodies and tail unit	CO 5	T1:5.3 R2:11.3
30	Cauchy-Reiman relation	CO 5	T1:5.3 R2:11.4
31	Complex conformal transformation	CO 5	T1:5.4
32	Kutta-Joukowski transformation	CO 5	T1:5.4
33	Kutta-Joukowski transformation	CO 5	T1:5.6
34	Introduction to boundary layer	CO 6	T3:4.1
35	Laminar and turbulent and transition boundary layer	CO 6	T3:4.2-4.3
36	Boundary layer on flat plate	CO 6	T3:18.2
37	Displacement thickness	CO 6	T3:4.5
38	Momentum thickness, Energy thickness	CO 6	T3:4.5
39	Energy thickness	CO 6	T3:4.6
40	Effect of curvature and Temperature boundary layer	CO 6	T3:4.7
PROBLEM SOLVING/ CASE STUDIES			
1	Calculate strength of source, sink , and vortex.	CO 1	R2:7.5
2	Calculate pressure and velocity distribution and lift of rotating cylinder	CO 1	T:3
3	Calculate strength of starting vortex	CO 1	T:3
4	Calculate the lift coefficient for thin airfoil	CO2	R2:7.5
5	Calculate the drag coefficient for thin airfoil	CO2	R2:7.6
6	Calculate the moment coefficient for thin airfoil	CO2	R2:7.7
7	Numerical problems related to lifting line theory	CO 3	R2:7.5
8	Numerical problems related to vortex panel method	CO 4	T1: 4.1
9	Numerical problems related to vortex lattic method	CO 4	T1: 4.2
10	Numerical problems related to flow singularities	CO 5	T2:6.5
11	Numerical problems related to conformal transformation	CO 5	T2:6.6
12	Numerical problems related to Joukowski transformation	CO 5	T2:6.7
13	Numerical problems relating to boundary layer thickness .	CO 6	T3:18.2
14	Numerical problems relating to momutum thickness .	CO 6	T3:18.3
15	Numerical problems relating to energy thickness .	CO 6	T3:18.4
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	potential flow, source, sink, flow over nonlifting and lifting bodies	CO 1,2,	T2: T2:104-167
2	Thin airfoil theory, airfoil nomenclature	CO 3,4	T4:7.3

3	Prandtls lifting line theory, wing twist, taper and sweep	CO 5,6	R4:5.1
4	Wing-body interference,Complex conformal transformation,Kutta-Joukowski transformation	CO 7,8	T1:7.5
5	Definition of boundary layer and separation, Bluff body and Streamlined body, Drag and lift	CO 9	T2: 7.1
DISCUSSION OF QUESTION BANK			
1	Module I	CO 1,2, 3	T2:104-167
2	Module II	CO 3,4	R2:8.1-8.3
3	Module III	CO 5,6	T1:5.2
4	Module IV	CO 7,8	R3:20.1
5	Module V	CO 9	T3: 4.1

Signature of Course Coordinator **HOD,AE**
Dr. Maruthupandiyan K Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**AEROSPACE STRUCTURES**				
Course Code	AAEC06				
Program	B.Tech				
Semester	IV				
Course Type	CORE				
Regulation	UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4		
Course Coordinator	Dr V Varun, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	Engineering Mechanics	I	Engineering Physics
B.Tech	Mechanics of Solids	III	Engineering Mechanics

II COURSE OVERVIEW:

Aerospace structures deal 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 a wing, fuselage, and landing gears have been introduced to analyze, design, and development of flight vehicles' structural components.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Aerospace Structures	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
20 %	Remember
40 %	Understand
25 %	Apply
15 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 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:

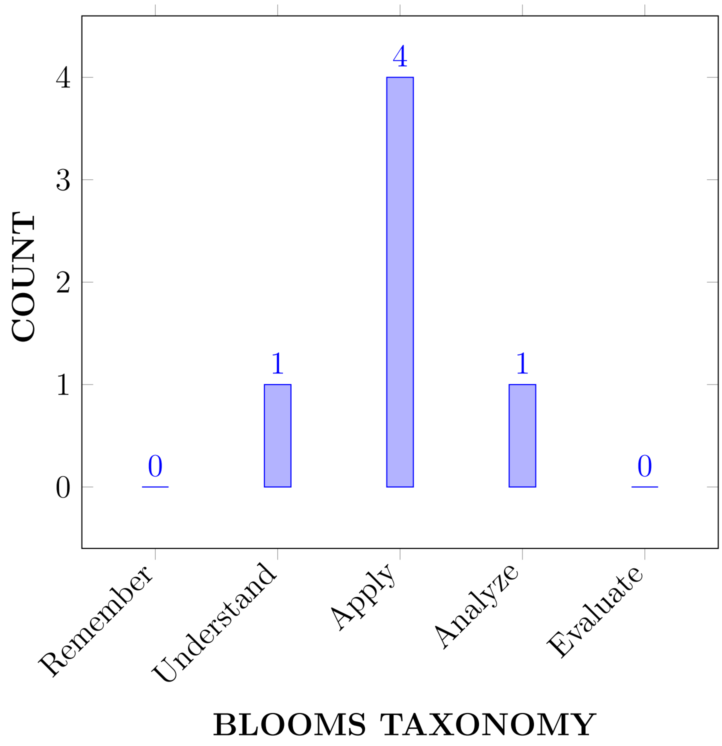
I	The application of mathematical principles on aircraft structural components and determination of deflections and stresses under various loading conditions.
II	The concepts of thin plate theory, phenomena of thin plate structural instability, analysis of bending, shear and torsion of thin walled beams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

VII COURSE OUTCOMES:

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

CO 1	**Utilize** the energy principles to aircraft structural components for interpreting minimal stress loading conditions.	Apply
CO 2	**Choose** the minimum energy principles and Fourier series solutions to thin rectangular plates subject to a given boundary conditions for predicting the stresses and strains.	Apply
CO 3	**Inspect** the deflection and twist produced in thin walled open and closed section beams under torsion loads for designing beams with minimum stresses.	Analyze
CO 4	**Develop** the elementary beam bending theory to thin walled open and closed section beams for predicting warping and torsion of aircraft structural components.	Apply
CO 5	**Illustrate** the concepts in structural idealization in transforming complex structural geometries to simple structural geometries used for interpreting the stress distribution on aircraft structures.	Understand
CO 6	**Make use of** maximum stress theories to aircraft structural components for determining failure stresses under various loading conditions.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2.8	CIE/SEE/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1.6	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	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards	3	Quiz
PSO 3	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	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	Apply the **knowledge of mathematics, engineering fundamentals**, to identify different aircraft components and loads acting on aircraft components using engineering specialization to the solution of complex engineering problems	2
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems related to aircraft loads in reaching substantiated conclusions using first **principles of mathematics, natural sciences, and engineering sciences**.	3
CO 2	PO 1	Apply the concept of thin plate theory used in structural Engineering to demonstrate deflections using the **principles of Mathematics,Science and Engineering fundamentals**.	3
	PO 2	Identify various theories related to thin plates and **formulate** the complex structural engineering problems and compare the deflection curves with various boundary conditions in reaching substantiated conclusions by the **interpretation of results**	3
CO 3	PO 1	Apply the **principles of Mathematics,and Engineering** to thin walled beams subjected to different loading conditions to predict deflections in complex engineering structures.	2
	PO 2	Design a thin-walled structures with use of **Mathematics,sciences and Engineering principles** to predict the stresses in out of plane	4
CO 4	PO 1	Apply the **principles of Mathematics, Science and Engineering** to predict the stresses produced in thin walled open and closed section beams used in aerospace structures.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Identify key features involved in open and closed section thin walled beams to analyze the deflections produced due to torsion using the **principles of Mathematics,Sciences and Engineering**	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.	1
CO 5	PO 1	Apply the knowledge of **Mathematics,Sciences and Engineering principles** to transform complex aircraft structures to simple geometrical structure to analyze the stresses and deflections produced due to loads.	3
	PO 4	Apply the **Engineering principles** for a given complex structural geometry and use the **Mathematical principles** to reduce it to simple geometry and verify the obtain results with existing literature.	5
CO 6	PO 1	Apply the **principles of Mathematics,Science and Engineering** to determine the stresses acting on an aircraft to avoid failures.	3
	PO 2	Identify various failure theories used in aircraft structural engineering and **formulate** the suitable method to **determine** stresses, collect the data related to various components and **vallidate** it with experimental data using the first **principles of Mathematics,Science and Engineering**	5
	PSO 1	Synthesize and analyze the failure loads in the aircraft structures, with use of computer aided tools to avoid damage and prolong the life of a structure	3

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	3	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	4	-	-	-	-	-	-	-	-	-		-	-	1
CO 5	3	-	-	5	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	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	66.7	30	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	40	-	-		-	-	-	-	-	-		-	-	34
CO 5	100	-	-	36	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	50	-	-	-	-	-	-	-	-	-	-	100	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	2	-	-	-	-	-	-	-	-	-	-	3
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
TOTAL	17	10	-	2	-	-	-	-	-	-	-	-	3	-	3
AVERAGE	2.8	1.6	-	2	-	-	-	-	-	-	-	-	3		3

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**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.

TEXTBOOKS

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.

REFERENCE BOOKS:

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.

WEB REFERENCES:

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COURSE WEB PAGE:

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XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
	Dicussion on Outcome based Education		
CONTENT DELIVERY (THEORY)			
1	Aircraft Structural components and loads.	CO1	T1:12.1
2	Functions of structural components, airframe loads.	CO1	T1:12.2
3	Types of structural joints, typeof loads on structural joints; Aircraft inertia loads.	CO1	T1:12.3
5	Symmetric maneuver loads, gust loads. Monocoque and semi monocoque structures, stress in thin and thick shells.	CO 1	T1:14.2 R2:4.25
8	Introductions to energy principles, castiglianos theorems, max wells reciprocal theorem, unit load method.	CO 1	T1:5.5 T1:5.10
7	Rayleigh Ritz method	CO 1	T1:5.6 T2:15.2
8	Total potential energy method	CO 1	T1:5.6 T2:15.2
9	Flexibility method.	CO 1	T1:5.6 T2:15.2
10	Flexibility method.	CO 1	T1:5.6 T2:15.2
11	Analysis of thin rectangular plates subject to bending, twisting, distributed transverse load.	CO 2	T2:5.6 R1:22.5
12	Combined bending and in-plane loading.	CO 2	T2:5.6 R1:22.5
13	Thin plates having small initial curvature, energy methods of analysis.	CO 2	T1:9.1 R1:22.6
14	Buckling of thin plates: Elastic, inelastic, experimental determination of critical load for a flat plate.	CO3	T1:9.1 R1:22.6
15	Local instability, instability of stiffened panels	CO 3	T2:18.20 T2:11.1

16	Failure stresses in plates and stiffened panels.	CO4 3	T2:18.20 T2:11.1
17	Tension field beams- complete diagonal tension.	CO 3	T2:18.20 T2:11.1
18	Incomplete diagonal tension, post buckling behavior.	CO 3	T2:18.20 T2:11.1
19	Unsymmetrical bending	CO 4	T1:16.1
20	Resolution of bending moments, direct stress distribution, position of neutral axis.	CO 4	T1:16.1
21	Deflections due to bending	CO 4	T1:16.6
22	Approximations for thin walled sections, temperature effects.	CO 4	T1:16.6
23	Temperature effects.	CO 4	T1:16.6
24	Shear loaded thin walled beams: General stress, strain and displacement relationships, direct stress and shear flow system, shear centre, twist and warping.	CO 4	T1:17.1
25	Torsion of beams of closed section: Displacements associated with Bredt-Batho shear flow; Torsion of open section beams.	CO 4	T2:6.4 R2:6.2
26	Warping of cross section, conditions for zero warping; Bending, shear, torsion of combined open and closed section beams.	CO 4	T1:18.1.2
27	Structural idealization, Principal assumptions.	CO 5	T1:20.1
28	Idealization of panel, effect on the analysis of thin walled beams under bending, shear, torsion loading.	CO 5	T1:20.2
29	Application to determining deflection of open and closed section beams.	CO 5	T1:16.3
30	Fuselage frames - bending, shear and torsion.	CO 5	T1:24.2
31	Wing spar and box beams.	CO 5	T2:22.5
32	Wing spar and box beams.	CO 5	T2:22.5
32	Wing spar and box beams.	CO 5	T2:22.5
34	Open and closed sections beams.	CO6	T1:27.1
35	Beams having variable stringer areas.	CO 6	T1:27.1
36	Beams having variable stringer areas.	CO 6	T1:27.1
37	Wings – three boom shell in bending, torsion and shear, tapered wings, deflections, cutouts in wings.	CO 6	T1:23.8 T2:19.14
38	Cutouts in fuselages; Fuselage frame and wing rib;	CO 6	T1:22.4, T2:5.18
39	principle of stiffener, web constructions.	CO 6	T1:22.4, T2:5.18
40	Landing gear and types; Analysis of landing gear.	CO 6	T1:22.4, T2:5.18
PROBLEM SOLVING/ CASE STUDIES			
1	Numerical problems on aircraft structural joints aand calculating rivet failure load	CO 1	R2:7.5
2	Numerical problems on aircraft loads	CO 1	R2:7.5
3	Numerical problems on Energy methods	CO 1	R2:7.5
4	Numerical problems on moments of thin plates, thin plates subjected to axial loads	CO 2	R2:7.5

5	Calculation of critical loads, Buckling of thin plates	CO 2	R2:7.5
6	Calculating loads on stiffned panels	CO 2	R2:7.5
7	Bending Moment,direct stresses in unsymmetrical beams	CO 3, CO 4	R2:7.5
8	Shear flow in thin walled beams subjected to torsion.	CO 3, CO 4	R2:7.5
9	Warping of thin walled beams using Bredt flow shear flow	CO 3, CO 4	R2:7.5
10	Structural idealization of thin walled panels subjected to direct stresses	CO 8, CO 5	R2:7.5
11	Deflection of open and closed section beams	CO 5	R2:7.5
12	Loads acting on fuselage frames due to bending and shear	CO 5	R2:7.5
13	Numerical problems on three-boom shells,variable stringer area.	CO 6,	R2:7.5
14	Torsion, bending and shear in tappered wings.	CO 6	R2:7.5
15	Cutouts in wings and fuselage sections.	CO 6	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Module I:INTRODUCTION TO AIRCRAFT STRUCTURAL COMPONENTS AND ENERGY METHODS	CO 1, CO 1	R2:7.5
2	Module II:THIN PLATE THEORY, STRUCTURAL INSTABILITY	CO 2	R2:7.5
3	Module III:BENDING, SHEAR AND TORSION OF THIN-WALLED BEAMS	CO 3, CO 4	R2:7.5
4	Module IV:STRUCTURAL IDEALIZATION	CO 5	R2:7.5
5	Module V:ANALYSIS OF FUSELAGE, WING AND LANDING GEAR	CO 6	R2:7.5
DISCUSSION OF QUESTION BANK			
1	Module I:INTRODUCTION TO AIRCRAFT STRUCTURAL COMPONENTS AND ENERGY METHODS	CO 1	R4:2.1
2	Module II:THIN PLATE THEORY, STRUCTURAL INSTABILITY	CO 2	T4:7.3
3	Module III:BENDING, SHEAR AND TORSION OF THIN-WALLED BEAMS	CO 3, CO 4	R4:5.1
4	Module IV:STRUCTURAL IDEALIZATION	CO 5	T1:7.5
5	Module V:ANALYSIS OF FUSELAGE, WING AND LANDING GEAR	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,AE**

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**AIRCRAFT PROPULSION**				
Course Code	AAEC07				
Program	B.Tech				
Semester	FOUR				
Course Type	Core				
Regulation	UG-20				
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 aircraft 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
Aircraft 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:

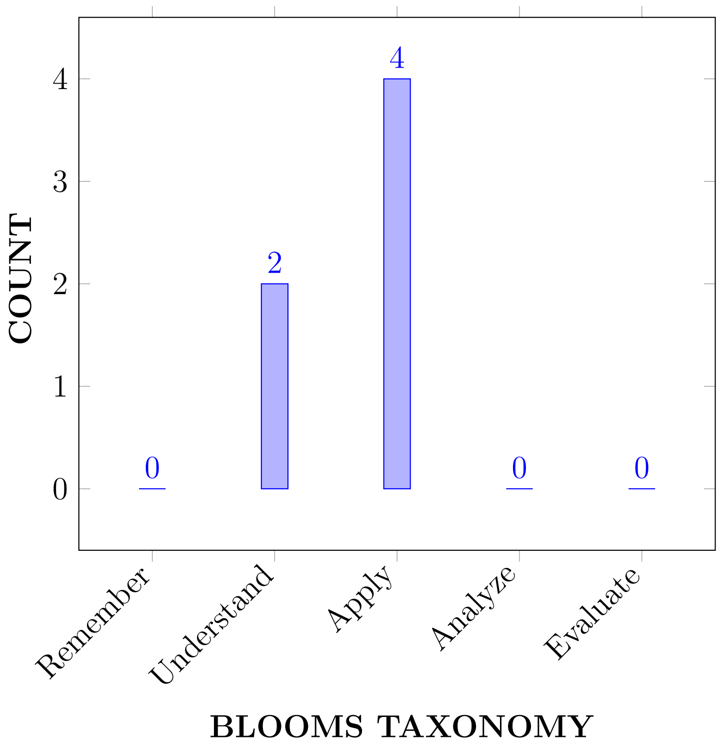
I	The fundamentals of air-breathing propulsion system, their operating principles, and function of an individual component.
II	The geometry of flow inlets, combustion chambers, and factors affecting their performance.
III	The establishment of flow through various inlets and nozzles under different operating 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.
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PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

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	
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
	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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	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
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	AAEC09				
Program	B.Tech				
Semester	IV				
Course Type	Core				
Regulation	UG-20				
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
Fluid Dynamics	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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33%	Understand
50 %	Apply
16 %	Analyze

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

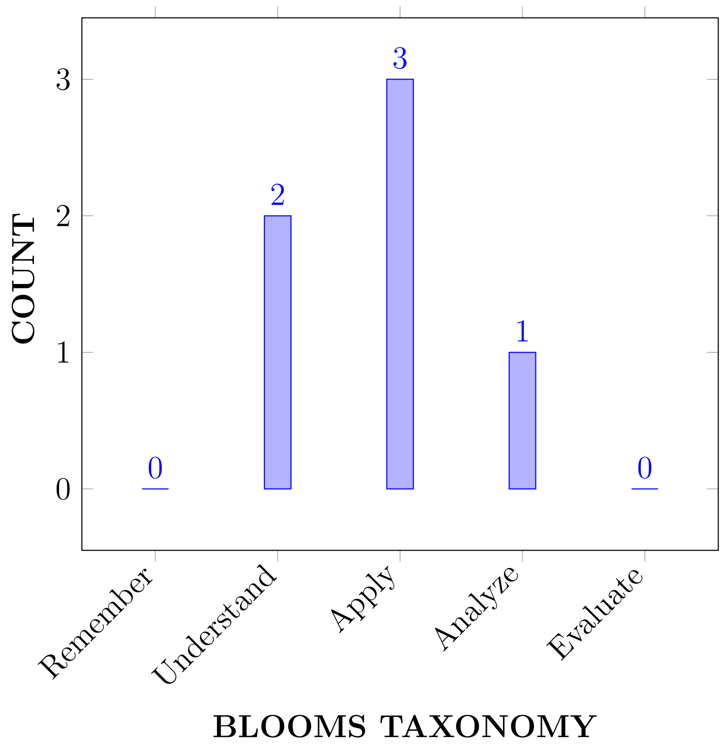
I	The fundamental principles of aerodynamics and propulsion for aircraft performance in classical flying stages.
II	The different regimes of aircraft and performance requirements at various atmospheric conditions.
III	The mathematical models for various types of maneuvers, safety requirements during 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	
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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.
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PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
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

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	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
	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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	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	-	-	-	-	-	-	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 2	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/details&course_id=105

COURSE WEB PAGE:

https://akanksha.iare.ac.in/index?route=course/details&course_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,AE**

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**AIRCRAFT PRODUCTION TECHNOLOGY**				
Course Code	AAEC10				
Program	B.Tech				
Semester	IV				
Course Type	CORE				
Regulation	UG 20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. I Seetharamarao, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSC06	II	Engineering Chemistry
B.Tech	AMEC01	II	Engineering Mechanics
B.Tech	AAEC01	III	Mechanics of Solids

II COURSE OVERVIEW:

The subject aircraft Production Technology provides knowledge regarding different types of manufacturing processes and materials used to produce variety of metal products used in aircraft industries. To make the student aware of various materials and production technologies generally involved in aircraft manufacturing. Further the engineer should be able to handle machine, equipment, tools and accessories in the recommended manner and also follow safety precautions.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Aircraft Production Technology	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 below table

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	The methods of improving the mechanical properties of aerospace materials and their alloys using heat treatment processes and corrosion prevention methods.
II	The concepts of welding, casting, forming, riveting process and quality inspection techniques used in manufacturing the aerospace components at low cost with minimum wastage.
III	The working principles, advantages and disadvantages of conventional and unconventional machining process used in aerospace industries.

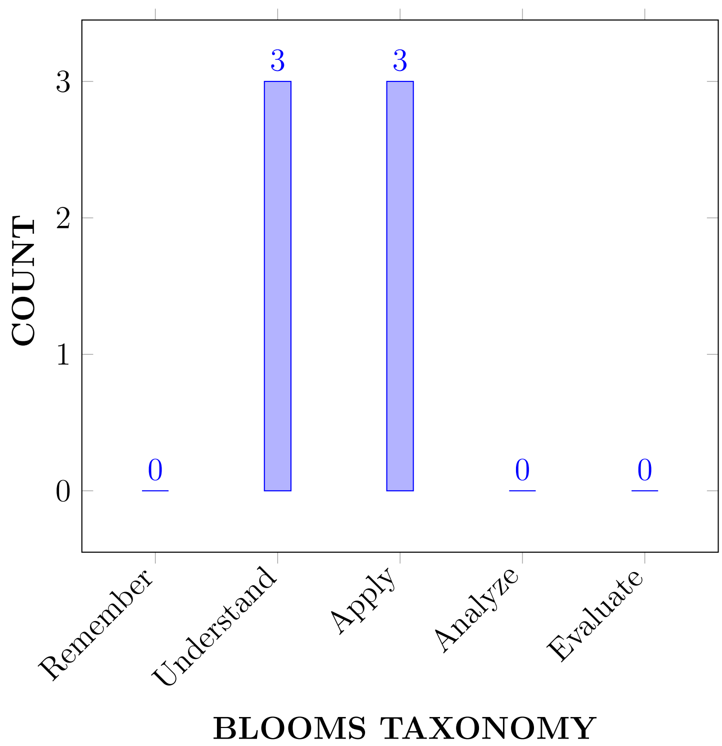
IV	The characteristics and applications of aircraft materials including composites used in aerospace industry.

VII COURSE OUTCOMES:

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

CO 1	**Illustrate** the engineering materials, heat treatment and corrosion prevention process for the enhancement of mechanical properties of aircraft components .	Understand
CO 2	**Demonstrate** the manufacturing processes and NDT testing methods viz, Dye penetrating technique, ultrasonic testing, magnetic particle inspections and radiography testing for producing defect free aircraft components.	Understand
CO 3	**Develop** the sheet metal operations and Riveting process in aerospace and automobile industries for assembling fuel tanks and components.	Apply
CO 4	**Make use** of machine tools and Jigs and fixtures used in manufacturing process for improving productivity with minimum cost of products in aircraft and allied industries.	Apply
CO 5	**Summarize** the principles and applications of non conventional machining process for selecting suitable processes based on design and materials of aircraft components.	Understand
CO 6	**Utilize** appropriate composite materials, Super alloys, indigenized alloys based on suitability and applications of aircraft components.	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.	2.16	CIE/SEE/AAT
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	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	CIE/SEE/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Focus on 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	Classify (knowledge) the engineering materials and heat treatment process used in manufacturing of aircraft components (apply) in solving aircraftstructural problems by applying the principles of science and Engineering.	2
	PO 7	Understand the (complex) impact of the professional engineering solutions societal and environmental contexts and demonstrate the(knowledge) of, and need for sustainable development	2
	PSO 2	Understand the (complex)various loading on aircraft assemblies at various conditions(information and data) is used for selecting materials and heat treatment process by the interpretation of results.	1
CO 2	PO 1	Explain (understanding) different sheet metal process (apply) in producing shapes of objects by applying the principles of mathematics, science, and engineering fundamentals. principles of mathematics, science and engineering fundamentals.	2
	PO 7	Understand the (complex) impact of the professional engineering solutions societal and environmental contexts and demonstrate the(knowledge) of, and need for sustainable development	2
	PSO 2	Apply (knowledge) of casting and welding process in solving aircraft designing problems by applying the principles of science and Engineering	1
CO 3	PO 1	Identify(apply) different sheet metal process in producing (complex) shapes of objects by applying the principles of mathematics, science and engineering fundamentals.	2
	PSO 2	Apply (knowledge) sheet metal process for making aircraft components by applying the principles of science and Engineering .	1
CO 4	PO 1	Extend (understanding) the use of Jigs and fixtures in manufacturing process (apply) for improving the productivity in aircraft industry by applying the principles of mathematics, science and engineering fundamentals.	2
	PO 12	Recognize(understanding) 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
	PSO 2	choose the machine tools for making aircraft components(understanding) by applying the principles of science and Engineering.	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 5	PO 1	Apply (knowledge) of CNC machines (understanding) in manufacturing process (apply) for production of aircraft components by applying the principles of mathematics,science and Engineering.	3
	PO 12	Recognize(understanding) 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
	PSO 2	Apply (knowledge) the principles and applications of non conventional machining process (apply) for selecting suitable processes based on materials of component by applying the principles of science and Engineering.	1
CO 6	PO 1	Recognize (knowledge) the materials and manufacturing process (understanding), subjected to various loading conditions (apply) in solving aircraft designing problems by applying the principles of science and Engineering fundamentals.	2
	PO 7	Understand the (complex) impact of the professional engineering solutions societal and environmental contexts and demonstrate the(knowledge) of, and need for sustainable development	2
	PO12	Recognize(understanding) 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
	PSO2	Apply (knowledge of) materials and manufacturing process to design the aircraft components in (apply) solving aircraft analysis problems by applying the principles of Mathematics, science and Engineering.	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	-	-	-	-	-	2	-	-	-	-	-	-	1	-
CO 2	2	-	-	-	-	-	2	-	-	-	-	-	-	1	-
CO 3	2	-	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	1	-	1	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	1	-	1	-
CO 6	2	-	-	-	-	-	2	-	-	-	-	1	-	1	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	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	-	-	-	-		-	1	-
CO 2	2	-	-	-	-	-	2	-	-	-	-	-	-	1	-
CO 3	2	-	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	1	-	1	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	1	-	1	-
CO 6	2	-	-	-	-	-	2	-	-	-	-	1	-	1	-
TOTAL	13	-	-	-	-	-	6	-	-	-	-	3	-	6	-
AVERAGE	2.16	-	-	-	-	-	2	-	-	-	-	1	-	1	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**AIRCRAFT ENGINEERING MATERIALS**
	Engineering materials Steels, study of iron, iron carbon phase diagram, heat treatment-annealing, normalizing, hardening and tempering of Aluminum and steel, Non-Ferrous metals and Alloys: Structure and properties of copper and its alloys, Aluminum and its alloys, Titanium and its alloys,Corrosion - Types of Corrosions - Prevention – Protective Treatments.
MODULE II	**CASTING, WELDING AND INSPECTION TECHNIQUES**
	General principles of various casting processes Sand casting, die-casting, centrifugal casting, investment casting, Shell molding types; Principles and equipment used in arc welding, gas welding, resistance welding, solid, laser welding, and electron beam welding, soldering and brazing techniques. Need for NDT, ultrasonic testing and Radiographic testing.
MODULE III	**SHEET METAL PROCESSES IN AIRCRAFT INDUSTRY**
	Sheet metal operations: shearing, punching, super plastic forming; operations in bending like stretch forming spinning drawing.Riveting, types and techniques, equipment, fasteners, integral tanks, final assembly of aircraft, Jigs and Fixtures, stages of assembly, aircraft tooling concepts.
MODULE IV	**CONVENTIONAL AND UNCONVENTIONAL MACHINING PROCESSES**
	General working principles, applications and operations of lathe, shaper, milling machines, grinding, drilling machine, computer numeric control machining.Working principles and applications of abrasive jet machining, ultrasonic machining, Electric discharge machining and electro chemical machining, laser beam, electron beam, plasma arc machining.
MODULE V	**AIRCRAFT COMPOSITES**
	Production of semi-fabricated forms, Aerospace applications, Plastics and rubber, Introduction to fiber reinforced plastics, glass and carbon composites; Fibers and resins; Characteristics and applications, Classification of aircraft materials; Materials used for aircraft components, Application of composite materials, Super alloys, indigenized alloys, emerging trends in aerospace materials.

TEXTBOOKS

1. S. Kalpakjian, Steven R. Schmid, “Manufacturing Engineering and Technology”, Addison Wesley 5th Edition, 1991.
2. S. C. Keshu, K. K Ganapathy, “Aircraft production technology and management”, Interline Publishing House, Bangalore, 3rd Edition, 1993.
3. Douglas F. Horne, “Aircraft production technology”, Cambridge University Press, 1st Edn, 1986.

REFERENCE BOOKS:

1. S. C. Keshu, K. K Ganapathy, “Air craft production techniques”, Interline Publishing House, Bangalore, 3rd Edition, 1993.
2. R. K. Jain, “Production technology”, Mc Graw Hill, 1st Edition, 2002.
3. O.P. Khanna, M. Lal, “Production technology”, Dhanpat Rai Publications, 5th Edn, 1997.

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 T2: 4.2
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=410
CONTENT DELIVERY (THEORY)			
2	Classification of Engineering materials	CO 1	T2:5.5 R1:1.12.1
3	study of iron and steels	CO 1	T2:5.5 R1:1.12.1
4	Iron carbon phase diagram	CO 1	T2:5.6 R1:1.12.3
5	Heat treatment-annealing, normalizing, hardening	CO 1	T2:5.10 R1:1.15
6	Tempering of Aluminum and steel	CO 1	T2:5.10 R1:1.15
7	Structure and properties of copper and its alloys, Aluminum and its alloys, Titanium and its alloys	CO 1	T2:5.15 R1:1.16
8	Corrosion - Types of Corrosions - Prevention – Protective Treatments	CO 1	T2:5.17 R1:1.13.1
9	General principles of various Casting Processes - Sand casting, die-casting	CO 2	T2:5.18 R2:1.13.2
10	centrifugal casting, investment casting.	CO 2	T2:5.18 R2:1.13.2
11	shell molding types	CO2	T2:5.19 R1:1.13.3
12	Principles and equipment used in arc welding	CO 2	T2:5.20 R1:1.17.1
13	Principles and equipment used in gas welding	CO 2	T2:5.20 R1:1.17.1
14	Laser welding , Electron beam welding	CO 2	T2:5.24 R1:1.17.3
15	Soldering and brazing techniques	CO 2	T2:6.1R1:2.3
16	Need for NDT, ultrasonic testing, Radiographic testing	CO 2	T2:6.3 R1:2.6.1
17	Sheet metal operations-shearing	CO 3	T2:6.5 R1:2.6.2
18	punching,	CO 3	T2:7.3 R1:2.8
19	super plastic forming diffusion bonding,	CO 3	T2:7.3 R1:2.8
20	Different operations in bending like stretch forming spinning drawing etc	CO 3	T2:7.5,7.6 R1:2.9.2
21	types of equipment for riveted joints	CO 3	T2:7.7 R1:2.10
22	fasteners, integral tanks	CO 3	T2:7.7 R1:2.10
23	Aircraft tooling concepts and stages of assembly Jigs and Fixtures	CO 4	T2:7.7 R1:2.10
24	Jigs and Fixtures	CO 4	T2:7.7 R1:2.10
25	General principles of working and types of lathe	CO 4	T2:7.11 R2:2.10.2
26	Shaper, milling machines	CO 4	T2:7.11 R2:2.10.2
27	Grinding, drills m/c, CNC machining and general principles.	CO 5	T2:7.11 R1:2.32
28	CNC machining and general principles.	CO 5	T2:7.11 R1:2.32
29	Plane turning, threading, tapering, grooving, knurling and chamfering	CO 4	T2:15.2 R1:8.2

30	Importance of CNC and Advantages	CO 5	T2:15.7 R2:8.3.3
31	Principles (with schematic diagram only) of working and applications of abrasive jet machining,	CO 5	T2:15.13 R1:8.7.2
32	USM, EDM, ECM and LBM operations	CO 5	T2:5.20 R1:1.17.1
33	Introduction, Physical metallurgy, Wrought aluminum alloys, Cast aluminum alloys	CO 6	T3:6.1 R1:2.3
34	Production of semi-fabricated forms	CO 6	T3:6.1 R1:2.3
35	Introduction to fiber reinforced plastics, glass and carbon Composites; Fibers and resins	CO 6	T2:6.3 R3:2.6.1
36	Characteristics and applications, Classification of aircraft materials;	CO 6	T2:6.5 R1:2.6.2
37	Materials used for aircraft components	CO 6	T2:7.3 R1:2.8
38	Application of composite material	CO 6	T2:7.3 R1:2.8
39	Super alloys, indigenized alloys	CO 6	T3:7.5,7.6 R3:2.9.2
40	emerging trends in aerospace materials	CO 6	T3:7.7 R3:2.10
PROBLEM SOLVING/ CASE STUDIES			
1	Illustrate iron-carbon phase diagram with all reactions clearly..	CO 1	T2:5.6 R1:1.12.3
2	Explain the how carbon content influence the strength and ductility of plain carbon steel	CO 1	T2:5.6 R1:1.12.3
3	Compare annealing and hardening. Explain how the microstructure of the ferrite materials varied by it?	CO 1	T2:5.10 R1:1.15
4	Name the types of centrifugal casting process and demonstrate the true centrifugal casting process and its advantages.	CO 2	T2:5.18 R2:1.13.2
5	Illustrate the different types of oxyacetylene flames with temperature. Write their applications.	CO 2	T2:5.20 R1:1.17.1
6	Classify types of nondestructive tests. Explain about the ultra- sonic testing process. What are their applications?	CO 2	T2:6.3 R1:2.6.1
7	Explain the operations: coining and embossing process. Outline the tools used in coining and embossing process	CO 3	T2:6.5 R1:2.6.2
8	Compare the advantages riveting over welding operation? Explain the procedure of riveting process with neat sketches.	CO 3	T2:7.7 R1:2.10
9	Explain the difference between jig and fixture? Write applications of jigs and fixture in production industries.	CO 4	T2:7.7 R1:2.10
10	Explain clearly with CNC machine and advantages of CNC over manual machining?	CO 5	T2:7.11 R1:2.32
11	Explain in detail the working and construction of plasma arc machining. Write the advantages and applications of plasma arc machining.	CO 5	T2:15.13 R1:8.7.2
12	Give explanation of laser beam machining by using neat sketch. Relate advantages, disadvantages and applications of laser beam machining.	CO 5	T2:5.20 R1:1.17.1

13	Summarize on each fiber which commonly used in aerospace industries and explain the importance of composites in manufacturing of the aircrafts.	CO 6	T2:7.3 R1:2.8
14	What are the advantages of composites over metals? Explain about their properties and load of impacts on them. Write the temperature settings on thermo setting plastics.	CO 6	T2:6.5 R1:2.6.2
15	List down the various materials used for aircraft components? Explain why composites are supposed to be used in airlines?	CO 6	T2:6.5 R1:2.6.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Mechanical properties,steel and cast iron,reactions in Iron-Carbon diagram,types of Heat treatment processes,types of corrosion and protective measures	CO 1	T2:5.6 R1:1.12.3
2	terminology used in casting,welding types	CO 2	T2:5.18 R2:1.13.2
3	Sheet metal operations,Jigs and Fixtures	CO 3,4	T2:6.5 R1:2.6.2
4	operations performed on Lathe and UNCONVENTIONAL MACHINING PROCESSES	CO 4,5	T2:7.11 R2:2.10.2
5	glass and carbon composites; Fibers and resins	CO 6	T2:6.3 R3:2.6.1
DISCUSSION OF QUESTION BANK			
1	Iron carbon phase diagram,Compare annealing and hardening,Estimation of corossion and its prevention.	CO 1	T2:5.10 R1:1.15
2	Demonstrate the steps involved in preparation moulding ,classification of welding process,types of non-destructive tests and its applications with an example?	CO 2	T2:6.1 R1:2.3
3	Discussion on various sheet metal operations,Aircraft tooling concepts,importance of JIgs and fixtures in aircraft industry,types of rivets and applications	CO 3,4	T2:7.3 R1:2.8
4	principle of Lathe ,functions of the important parts of lathe,Grinding,Shaping,Milling, CNC machine and advantages of CNC over manual machining,principle of Electric Discharge Machining	CO 4,5	T2:7.11 R1:2.32
5	major applications of composite materials in aircraft industry, isotropic, anisotropic, and orthotropic materials,properties of metal matrix composites	CO 6	T2:6.3 R3:2.6.1

Signature of Course Coordinator **HOD,AE**
Mr. I.Seetharamarao, Assistant Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**AERODYNAMICS AND PROPULSIONLABORATORY**				
Course Code	AAEC12				
Program	B.Tech				
Semester	IV	AE			
Course Type	Core				
Regulation	IARE - UG20				
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:

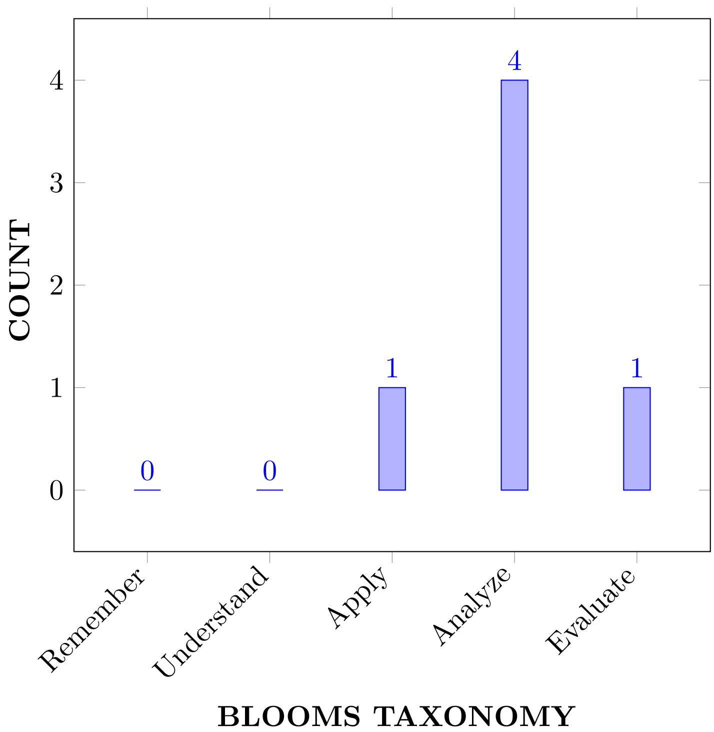
I	To understand the behaviour of flow properties over different models using subsonic wind tunnel.
II	To demonstrate experimentally the pressure distribution over circular, symmetric and cambered aerofoils and evaluate lift and drag.
III	To illustrate flow visualization studies at low speeds over different 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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**AIRCRAFT PRODUCTION TECHNOLOGY LABORATORY**				
Course Code	AAEC13				
Program	B.Tech				
Semester	IV	AE			
Course Type	CORE				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Mr.I.SEETHARAMARAO, Assistant Professor				

I COURSE OVERVIEW:

The Aircraft Production Technology lab encompasses on providing sound practical knowledge on testing of engineering material and conventional machining process which plays a vital role in designing the components with minimum cost and with longer service.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC02	II	Manufacturing Practice

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Aircraft Production Technology	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	Understand the basic material properties to identify the suitable applications in aerospace industries.
II	Illustrate other conventional machining techniques required for aircraft production.
III	Learn the tooling and material joining technique used in aircraft assembly.

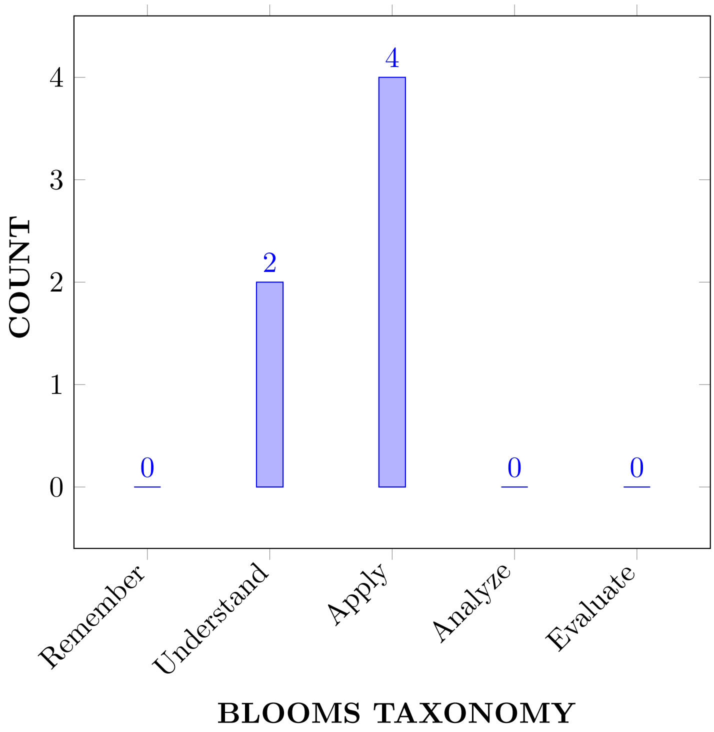
VII COURSE OUTCOMES:

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

CO 1	**Identify** the microstructures of the materials for selecting the suitability in industrial applications. .	Apply
CO 2	**Illustrate** various jobs for joining the materials using welding operation in real time applications.	Understand
CO 3	**Identify** the types of machining process required for producing desired shape of components used in Aerospace and allied industries.	Apply

CO 4	**Demonstrate** molding processes and their application for producing machine components used in industries.	Apply
CO 5	**Select** the suitable tools and process parameters required in machining, drilling and slotting operations for producing components with minimum cost.	Understand
CO 6	**Illustrate** various jobs for joining the materials using Riveting operation in industries.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	CIA

PO 7	**Environment and sustainability: :** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	1	CIA
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	**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 2	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	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	identifying the microstructure (understanding) their importance and **application** (apply) in industries by applying the **principles of science and Engineering**	2
	PO 6	Apply reasoning informed by the contextual knowledge to assess societal and health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice and need for **sustainable development**	1
	PO 7	Understand the (complex)impact of the professional engineering solutions **societal and environmental contexts** and demonstrate the (knowledge) of, and need for sustainable development.	1
	PO 9	Understand the given (problem statement)job effectively as an **individual** and Instruction on **effective teamwork** and **project management** is provided along with an appropriate textbook for reference.	3
	PO 10	Recognize(understanding) the need for **clarity(writing)** and write effective reports and **design documentation, make effective presentations,** and give and receive clear instructions.	2

	PSO 2	Apply various loading on aircraft assemblies at various conditions for the given **information and data** is used for selecting materials and heat treatment process by the interpretation of results.	1
CO 2	PO 1	Identify (knowledge) suitable methods involved during welding for error free components by applying **Scientific principles and methodology**	2
	PO 6	Knowledge and understanding of different welding techniques and **economic context of engineering processes**	1
	PO 7	Understand the (complex)impact of the professional engineering solutions **societal and environmental contexts** and demonstrate the (knowledge) of, and need for sustainable development.	1
	PO 9	Understand the given (problem statement)job effectively as an **individual** and Instruction on **effective teamwork** and **project management** is provided along with an appropriate textbook for reference.	3
	PO 10	Recognize(understanding) the need for **clarity(writing)** and write effective reports and **design documentation, make effective presentations,** and give and receive clear instructions.	2
CO 3	PO 1	Extend (understanding) the use of Jigs and fixtures in manufacturing process (apply) for improving the productivity in aircraft industry by applying the principles of science and engineering fundamentals.	2
	PO 6	Apply reasoning informed by the contextual knowledge to assess societal and health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice and need for **sustainable development**	1
	PO 7	Understand the (complex)impact of the professional engineering solutions **societal and environmental contexts** and demonstrate the (knowledge) of, and need for sustainable development.	1
	PO 9	Understand the given (problem statement)job effectively as an **individual** and Instruction on **effective teamwork** and **project management** is provided along with an appropriate textbook for reference.	3
	PO 10	Recognize(understanding) the need for **clarity(writing)** and write effective reports and **design documentation, make effective presentations,** and give and receive clear instructions	2
CO 4	PO 1	Recognize (knowledge) the importance and application (apply) of dimensions, units and dimensional homogeneity in solving (complex) engineering problems with specific emphasis to fluid mechanics by applying the **principles of Mathematics, Science and Engineering**	2

	PO 6	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	1
	PO 7	Understand the (complex)impact of the professional engineering solutions **societal and environmental contexts** and demonstrate the (knowledge) of, and need for sustainable development.	1
	PO 9	Understand the given (problem statement)job effectively as an **individual** and Instruction on **effective teamwork** and **project management** is provided along with an appropriate textbook for reference.	3
	PO 10	Recognize(understanding) the need for **clarity(writing)** and write effective reports and **design documentation, make effective presentations,** and give and receive clear instructions	2
CO 5	PO 1	Apply the basic conservation laws of science for various phenomena of fluid systems and use **mathematical principles** for deriving (complex) fluid flow engineering equations by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals** of fluid mechanics.	2
	PO 6	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.	1
	PO 7	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.	1
	PO 9	Understand the given (problem statement)job effectively as an **individual** and Instruction on **effective teamwork** and **project management** is provided along with an appropriate textbook for reference.	3
	PO 10	Recognize(understanding) the need for **clarity(writing)** and write effective reports and **design documentation, make effective presentations,** and give and receive clear instructions	2
CO 6	PO 1	Apply (knowledge) sheet metal process for making aircraft components by applying the principles of science and Engineering .	2
	PO 6	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.	1

	PO 7	Understand the (complex)impact of the professional engineering solutions **societal and environmental contexts** and demonstrate the (knowledge) of, and need for sustainable development.	1
	PO 9	Understand the given (problem statement)job effectively as an **individual** and Instruction on **effective teamwork** and **project management** is provided along with an appropriate textbook for reference.	3
	PO 10	Recognize(understanding) the need for **clarity(writing)** and write effective reports and **design documentation, make effective presentations,** and give and receive clear instructions	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 6	PO 7	PO 9	PO 10	PSO 2
CO 1	2	1	1	3	2	1
CO 2	2	1	1	3	2	
CO 3	2	1	1	3	2	
CO 4	2	1	1	3	2	
CO 5	2	1	1	3	2	
CO 6	2	1	1	3	2	

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1, PO 7, PSO 2	SEE Exams	PO 1,PO 7, PO 9, PSO 2	Seminars	-
Laboratory Practices	PO 1,PO 6, PO 7, PO 12 PSO 2	Student Viva	PO 1, 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	**BASIC METALLURGY -I**
	Preparation and study of microstructure of pure materials like Cu and Al.
WEEK II	**BASIC METALLURGY -II**
	a. Study of microstructures of non-ferrous alloys. b. 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**
	Shaping-V-Block.
WEEK VI	**SLOTTING**
	Slotting-Keyways.
WEEK VII	**MILLING**
	Milling-Face milling, End milling and Side milling.
WEEK VIII	**GRINDING**
	Grinding-Cylindrical or Surface or Tool and cutter.
WEEK IX	**DRILLING**
	Drilling, reaming, counter boring, Counter sinking and Taping
WEEK X	**WELDING PROCESS-I**
	Gas Welding, Brazing and Soldering.
WEEK XI	**WELDING PROCESS-II**
	Arc welding and Spot welding
WEEK XII	**BASIC CASTING**
	Preparation of casting with simple patterns.

TEXTBOOKS

1. S. Kalpakjian, Steven R. Schmid, —Manufacturing Engineering and Technology‖, Addison Wesley 5th Edition, 1991.

2. S. C. Keshu, K. K Ganapathy, —Aircraft production technology and management‖, Interline Publishing House,Bangalore, 3rd Edition, 1993.

3. Douglas F. Horne, —Aircraft production technology‖, Cambridge University Press, 1st Edition, 1986.

REFERENCE BOOKS:

1. S. C. Keshu, K. K Ganapathy, —Air craft production techniques‖, Interline Publishing House, Bangalore, 3rd Edition,1993.

2. R. K. Jain, —Production technology‖, McGraw Hill, 1st Edition, 2002

3. O. P. Khanna, M. Lal, —Production technology‖, DhanpatRai Publications, 5th Edition, 1997.

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Prepare the Mounted specimen and study of microstructure of pure Metal like Cu/Fe/Al.	CO 1	T1: 1.2
2	Prepare the Mounted specimen and study of microstructure of Heat treated Steel.	CO 1	T1: 1.2
3	Prepare a V – Butt Joint using Electric Arc Welding Process.	CO 2	R1: 3.4
4	Prepare a Butt Joint using Gas Welding Process and Brazing process	CO 2	R1: 2.2
5	Perform the drilling, tapering and boring operations on a circular rod so as to obtain the required dimensions using lathe machine.	CO 3	R1: 2.4
6	Perform the External Threading and Knurling operations on a circular rod so as to obtain the required dimensions using lathe machine.	CO 3	R3: 4.5
7	Prepare a Aluminium Casting for the given Solid Pattern using Green Sand Moulding Processes.	CO 4	R3: 4.6
8	Perform the boring and reaming operation on a rectangular work piece so as to obtain the required dimensions using drill machine.	CO 5	T2: 5.1
9	Perform the slot and groove operation on a rectangular work piece so as to obtain the required dimensions using slottingl machine.	CO 5	R2: 5.2
10	Perform the Making of Dovetail on a work piece so as to obtain the required dimensions using shaping machine.	CO 5	R1: 7.1
11	Perform cylindrical surface grinding on a cylindrical work piece so as to obtain the required dimensions using cylindrical surface grinding machine.	CO 6	R1:7.2
12	Perform the Face milling and Side milling on a rectangular work piece so as to obtain the required dimensions using vertical milling machine.	CO 6	T1:7.3

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. I Seetarama Rao, Assistant Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**AEROSPACE STRUCTURES LABORATORY**				
Course Code	AAEC11				
Program	B.Tech				
Semester	IV	AE			
Course Type	Elective				
Regulation	IARE - UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	C Sushmitha,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
AEROSPACE STRUCTURES	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 .

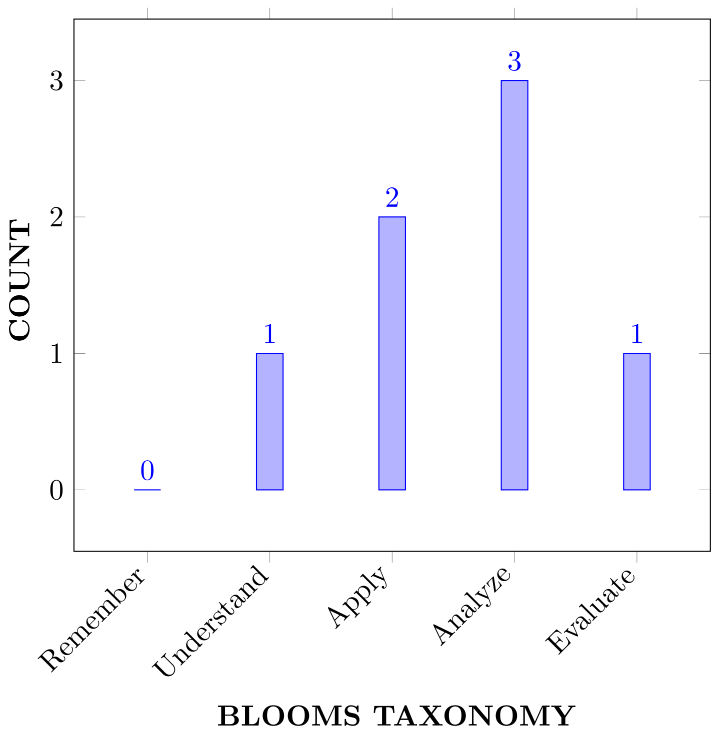
II	The identification of crack/flaws using Non Destructive Testing (NDT) methods for choosing proper materials in engineering applications .
III	Understand the concept of shear centre for open and Closed section beams for avoiding torsion.
IV	Obtain buckling strength of both long and short columns using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

VII COURSE OUTCOMES:

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

CO 1	**Examine** the deflection produce due to various end conditions of beams, verify maxwells reciprocal theorem, Stress-Strain curve for various materials for obtaining the minimum stress. .	Apply
CO 2	**Compare** the buckling strength for short and long columns with various end conditions and verify it with Euler's formula for designing of beams used in aerospace structures.	Apply
CO 3	**Assess** the deflection of beams in out of plane(unsymmetrical bending), and obtain the location of shear center for a given beam section for designing of beams with minimum stresses and location of loading point to decouple torsion and deflection.	Understand
CO 4	**Utilize** the wagner theorem to determine the buckling stresses under shear, and determine the young's modulas of a fabricated sandwitch structure for designing of beams to avoid failures and to optimize the weight and strength of a sandwitch structure.	Apply
CO 5	**Utilize** Dye penetration test, magnetic particle test,and ultrsonic technique to inspect the cracks on a materials for characterizing a crack to avoid failures under static and dynamic loading conditions.	Apply
CO 6	**Inspect** the natural frequencies of beams under free and force vibration for designing of a structure to avoid failure due to resonance.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises
PO 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 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
	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
	PO 10	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 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) 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 2	Apply (**knowledge**) Newtons law of viscosity (understanding) in body, under different inlet conditions in (apply) solving flow through pipes by applying the principles of **Mathematics, Science and Engineering**	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

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 6	PO 9	PO 10	PSO 2
CO 1	3	2	3			3	2
CO 2	3	2	2			3	2
CO 3	3	2	2			3	2
CO 4	3	2	2			3	3
CO 5	3	2	3			3	3
CO 6	3	2	3			2	2

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,stress strain curves and strength test for various engineering materials.
WEEK II	**DEFLECTION TEST-I**
	Deflections of beams for various end conditions, verification of Maxwell‘s theorem.
WEEK III	**BUCKLING TEST-I**
	Compression tests on long columns, Critical buckling loads.
WEEK IV	**BUCKLING TEST-II**
	Compression tests on short columns, Critical bucklingloads, southwell plot.
WEEK V	**IMPACT OF JET ON VANES**
	Deflection of unsymmetrical beams.
WEEK VI	**SHEAR CENTRE FOR OPEN SECTION BEAMS**
	Shear Centre of a Closed Section beams.
WEEK VII	**SHEAR CENTRE FOR ClOSED SECTION BEAMS**
	Shear Centre of a Closed Section beams.
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-DESTRUCTIVE TESTING-I**
	Study of non-destructive testing procedures using dye penetration.
WEEK XI	**NON-DESTRUCTIVE TESTING-II**
	Magnetic particle inspection and ultra sonic techniques.
WEEK XII	**VIBRATION TEST**
	Determination of natural frequency of beams under free and forced vibration using vibration test equipment.

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

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	R1: 1.2
2	Verification of Maxwell's theorem to calculate deflections of beams with various end conditions.	CO 2	R2: 3.5
3	Determination of Critical buckling loads by Compression tests on long columns .	CO 3	R1: 3.4

4	Determination of Critical buckling loads, Southwell plot by Compression tests on short columns.	CO 4	R1: 2.2
5	Determine unsymmetrical Bending of a Beam.	CO 5	R1: 2.4
6	Determination of Shear Centre of an Open Section beam.	CO 6	R3: 4.5
7	Determination of Shear Centre of a Closed Section beam.	CO 6	R3: 4.6
8	Wagnerbeam–Tension field beam.	CO 6	R2: 5.1
9	Fabrication and determination of young's modulus of a sandwich structures.	CO 6	R2: 5.2
10	Study of non-destructive testing procedures using dye penetration.	CO 7	R1: 7.1
11	Magnetic particle inspection and ultrasonic techniques.	CO 7	R1:7.2
12	Determination of natural frequency of beams under free and forced vibration.	CO 7	R1:7.3

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

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

Signature of Course Coordinator **HOD,AE**
C Sushmitha,Assistant Professor

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

COURSE DESCRIPTION

Department	**Aeronautical Engineering**				
Course Title	**Business Economics and Financial Analysis**				
Course Code	AHSC13				
Program	B.Tech				
Semester	V				
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr.M.Sindu,Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

II COURSE OVERVIEW:

The present course is designed in such a way that it gives an overview of concepts of Economics. Managerial Economics enables students to understand micro environment in which markets operate how price determination is done under different kinds of competitions. Financial Analysis gives clear idea about concepts, conventions and accounting procedures along with introducing students to fundamentals of ratio analysis and interpretation of financial statements. Break Even Analysis is very helpful to the Business Concern for Decision Making, controlling and forward Strategic Planning. Ratio analysis gives an idea about financial forecasting, financial planning, controlling the business and decision making.

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
16.67%	Remember
16.67%	Understand
16.67%	Apply
50 %	Analyze
0 %	Evaluate
0 %	Create

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

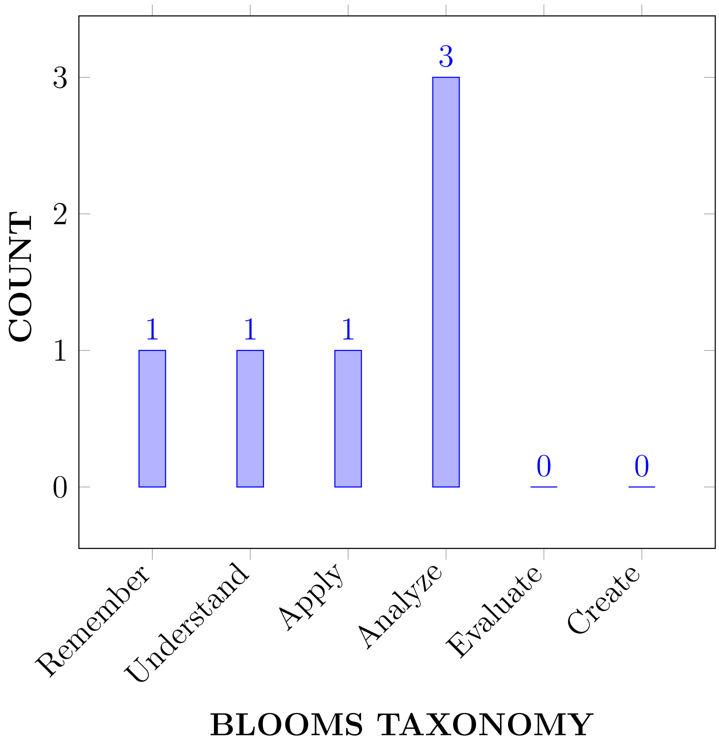
I	The concepts of business economics and demand analysis helps in optimal decision making in business environment
II	The functional relationship between Production and factors of production and able to compute breakeven point to illustrate the various uses of breakeven analysis.
III	The features, merits and demerits of different forms of business organizations existing in the modern business environment and market structures.
IV	The concept of capital budgeting and allocations of the resources through capital budgeting methods and compute simple problems for project management.
V	Various accounting concepts and different types of financial ratios for knowing financial positions of business concern.

VII COURSE OUTCOMES:

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

CO 1	**List** the basic concepts of managerial economics and analysis, measurement of demand and its forecasting to know the current status of goods and services.	Remember
CO 2	**Examine** to know the current status of goods and services. to know the economies and diseconomies of scale in manufacturing sector.	Analyze
CO 3	**Summarize** the four basic market models like perfect competition, monopoly, monopolistic competition, and oligopoly to know the price and quantity are determined in each model.	Understand
CO 4	**Compare** various types of business organizations and discuss their implications for resource allocation to strengthen the market environment.	Analyze
CO 5	**Analyze** different project proposals by applying capital budgeting techniques to interpret the solutions for real time problems in various business projects.	Analyze
CO 6	**Develop** the ability to use a basic accounting system along with the application of ratios to create (record, classify, and summarize) the data needed to know the financial position of the organization.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	1	Seminar/ Conferences
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	Assignments/ Discussion
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	3	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	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

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Recall** (knowledge) the scientific fundamentals of economic activities performed by the businessmen in the business for profit earning.	2
	PO 2	**Interpret** and identify the demand and its analysis with the mathematical and natural principles of demand forecasting methods.	6
	PO 8	**Define** (knowledge) the responsibilities of the engineering practices by knowing the best economical practices.	1
	PO 9	**Match** (knowledge) the economical implication to effectively function as a team member, and as a member or leader in diverse teams.	5

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 11	**Relate** (knowledge) the knowledge and understanding of the economic principles and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	6
CO 2	PO 1	**Recall** (Knowledge) the knowledge of mathematics, science in the production function through Different Combination of variable inputs with Economies of Scale.	2
	PO 2	**Demonstrate** the different cost concepts and determine the significance of Break Even Analysis.	5
	PO 8	**Relate** (Knowledge) (Knowledge) the ethical principles and commit to professional ethics and responsibilities and norms of the production management	2
	PO 9	**Show** (Fundamentals) the production function implications for effective implementation of gang compositions in a team work and in multidisciplinary settings.	6
	PO 11	**Define** the economies of scale in production function and Break Even Analysis knowledge applied in one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	5
CO 3	PO 8	**List** (Knowledge) (Knowledge) different structures of market and how price is determined under different market structures commit to professional ethics and responsibilities and norms of the engineering practice.	2
	PO 9	**Match** the market structures and the market entry strategies as an individual, and as a member in diverse teams.	6
CO 4	PO 8	**Categorize** the ethical principles and commit to professional ethics and responsibilities belongs to different forms of business organizations existing in the modern business.	2
	PO 9	**Classify** various business organizations and their functioning as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	6
CO 5	PO 1	**Explain** the ethical issues involved in the allocation of funds under the concept of capital budgeting.	1
	PO 11	**Summarize** the concept of capital budgeting and allocations of the resources through capital budgeting methods of the management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	8
CO 6	PO 2	**Explain** the GAAP principles and ratios to analyse complex engineering problems reaching substantiated conclusions using first principles of accounts and profitability and efficiency of the organization.	6

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 11	**Illustrate**the accounting methods and procedures and accounting principles to manage the financial aspects in a project.	8

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	60.0	-	-	-	-	-	33.3	41.6	-	50.0	-	-	-	-
CO 2	66.7	50.0	-	-	-	-	-	66.7	50.0	-	41.6	-	-	-	-
CO 3	-	-	-	-	-	-	-	66.7	50.0	-	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	66.7	50.0	-	-	-	-	-	-
CO 5	33.3	-	-	-	-	-	-	-	-	-	75.0	-	-	-	-
CO 6	-	20.0	-	-	-	-	-	-	-	-	75.0	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
TOTAL	7	7	-	-	-	-	-	10	8	-	-	-	-	-	-
AVERAGE	2.3	2.3	-	-	-	-	-	2.5	2	-	2.5	-	-	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**INTRODUCTION&DEMAND ANALYSIS**
	Introduction to Business Economics: Definition, Nature and Scope of Managerial Economics – Demand Analysis: Demand Determinants, Law of Demand and its exceptions. Elasticity of Demand: Definition, Types, Measurement and Significance of Elasticity of Demand. Demand Forecasting, Factors governing demand forecasting, methods of demand forecasting
MODULE II	**PRODUCTION & COST ANALYSIS**
	Theory of Production and Cost Analysis: Production Function – Iso-quants and Iso-costs, MRTS, Least Cost Combination of Inputs, Cobb-Douglas Production function, Laws of Returns, Internal and External Economies of Scale. Cost Analysis: Cost concepts; Break-even analysis, Determination of Break – Even point (Simple Problems) , Managerial Significance of BEA.
MODULE III	**MARKETS & NEW ECONOMIC ENVIRONMENT**
	LMarket structures: Types of competition, Features of perfect competition, Monopoly and monopolistic competition. Price determination & Price Statistics: Price Output determination in case of perfect competition and monopoly. Features and evaluation of different forms of Business organization: Sole proprietorship, partnership, Joint Stock Company, public enterprises and their types.
MODULE IV	**CAPITAL BUDGETING**
	Capital and its significance, types of capital, estimation of fixed and working capital requirements, methods and sources of raising capital- Trading Forecast, Capital budget, Cash Budget. Features of capital budgeting proposals, methods of capital budgeting – payback method, Accounting rate of return(ARR), Net Present Value Method (simple problems).

MODULE V	**INTRODUCTION TO FINANCIAL ACCOUNTING AND FINANCIAL ANALYSIS**
	Financial accounting objectives, functions, importance; Accounting concepts and accounting conventions - double-entry book keeping, journal, ledger, trial balance; Final accounts: Trading account, profit and loss account and balance sheet with simple adjustments; Financial analysis: Analysis and interpretation of liquidity ratios, activity ratios, capital structure ratios and profitability ratios (simple problems), Du Pont chart.

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2. M. KasiReddy, Saraswathi, “Managerial Economics and Financial Analysis”, PHI Publications, New Delhi, 2ndEdition,2012.
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5. https://www.vedantu.com/commerce/various-forms-of-business-organisations
6. https://courses.lumenlearning.com/boundless-finance/chapter/introduction-to-capital-budgeting/
7. https://jkbhardwaj.com/20-transactions-with-their-journal-entries-ledger-and-trial-balance/
8. https://www.iedunote.com/write-accounting-ledger
9. https://opentextbc.ca/principlesofaccountingv1openstax/chapter/prepare-a-trial-balance/
10. https://caknowledge.com/how-to-prepare-final-accounts/
11. https://corporatefinanceinstitute.com/resources/knowledge/finance/ratio-analysis/

COURSE WEB PAGE:

https://lms.iare.ac.in/index?route=publicprofile&id=5201

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Discussion on Course Outcomes and how these COs mapped with POs and PSOs.		
CONTENT DELIVERY (THEORY)			
2-3	Explain about managerial economics according to the business	CO 1	T1- 1.3-1.8 R1-1.5-1.7
4-5	Describe about demand analysis, the Law of Demand and Demand Function.	CO 1	T1-2.2-2.11 R1-3.3-3.20
6-7	Understand elasticity of the demand of the product, different types, Measurement of Elasticity of Demand and Factors influencing on Elasticity of Demand.	CO 1	T1-3.3-3.20 R1- 5.29-6.8
8	State different methods of Demand Forecasting and the factors governing Demand Forecasting.	CO 1	T1-4.6-4.19
9-10	Demonstrate the Production function, features of Iso-Quants and Iso-Costs, different types of Internal Economies, External Economies and Law of Returns.	CO 2	T1- 5.3-5.18 R1- 5.29-6.8
11-13	Different types of Internal Economies, External Economies ad Law of Returns with appropriate examples.	CO 2	T1- 5.3-5.18
14-15	Illustrate different types of costs	CO 2	T1- 5.29-6.8
16-17	Explain the Significance and Limitations of Break-Even Analysis	CO 2	T1- 7.13-7.14
18-19	Calculate Break-Even Point (Simple Problems)	CO 2	T1- 7.1-7.12
20-21	Illustrate the features, price-output determination under Perfect Competition, Monopoly and Monopolistic competition Markets.	CO 3	T1- 8.4-8.16 R2- 5.29-6.8
22-24	Demonstrate the Objectives, Policies and Methods of Pricing Strategies and Price Methods.	CO 3	T1- 8.21-8.25
25-26	Describe Features of business, Definitions of Various forms of Business Units.	CO 4	T1-9.3-9.15
27-30	State the Merits & Demerits of Different types of Public Enterprises and Changing Business Environment to Post Liberalization Scenario.	CO 4	T1-9.2-10.23 R1- 8.21-8.25
31-32	Explain the significance and classification of capital, Methods and Sources of Raising Finance.	CO 6	T1-9.2-10.23
33-34	Demonstrate the concept of capital budgeting and allocations of the resources through capital budgeting methods and compute simple problems.	CO 6	T1-11.3-11.5 R2-12.3-12.5
35-37	Illustrate the Significance of Financial Accounting, Double Entry, Accounts, Accounting Concepts and Conventions	CO 6	T1-12.1-12.26
38-40	Explain the meaning, advantages and Limitations of the Journal, Ledger and Trial Balance and Final Accounts and Solve simple Problems.	CO 6	T1-13.4-13.15 R2-11.3-11.5
41-42	Describe Meaning, Definitions and Limitations of Ratio Analysis	CO 6	T1-13.4-13.15 R2-11.7-11.8

43-45	Compute different types of Financial Ratios (Problems)	CO 6	T1-13.5-13.68
PROBLEM SOLVING/ CASE STUDIES			
46	Problems relating to Demand elasticty measurement and Forecasting	CO 1	T1: 1.1 - 2.8, R1:2.1
47	Problems relation to Break Even Point	CO 2	T2: 3.0 to 3.6, 5.0 to5.5 , R2:4.4
48	Problems in determining the price in different types of markets	CO 3,4	T3: 6.0 to 6.4, R1:5.1
49	Problems relating to Capital Budgeting Decisions	CO 5	R2:7.5
50	Problems relating to Final Accounts and Calculation of Ratios	CO 6	R3: 4.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
51	Introduction and Demand Analysis	CO 1	T1: 1.1 - 2.8, R1:2.1
52	Production and Cost Analysis	CO 2	T2: 3.0 to 3.6, 5.0 to5.5 , R2:4.4
53	Markets and New Environment	CO 3,4	T3: 6.0 to 6.4, R1:5.1
54	Capital Budgeting	CO 5	R2:7.5
55	Introduciton to Financial Accounting and Financial Analysis	CO 6	R3: 4.1
DISCUSSION OF QUESTION BANK			
56	Introduction and Demand Analysis	CO 1	T1: 1.1 - 2.8, R1:2.1
57	Production and Cost Analysis	CO 2	T2: 3.0 to 3.6, 5.0 to5.5 , R2:4.4
58	Markets and New Environment	CO 3,4	T3: 6.0 to 6.4, R1:5.1
59	Capital Budgeting	CO 5	R2:7.5
60	Introduciton to Financial Accounting and Financial Analysis	CO 6	R3: 4.1

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

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**AEROSPACE PROPULSION**				
Course Code	AAEC14				
Program	B.Tech				
Semester	V				
Course Type	Core				
Regulation	UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. Lakshmi Srinivas, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEC07	IV	Aircraft Propulsion

II COURSE OVERVIEW:

Aerospace propulsion focuses on fundamental knowledge of conceptual planetary and solar systems, propulsion, and control systems used in the mission design of launch vehicles. This subject motivates to gain knowledge of chemical rocket propulsion for scientific and practical purposes. The course includes the combustion process, propellants, and various components and applications of chemical rocket propulsion systems. This course deals with fundamental aspects of advanced rockets and the current trends in rocket propulsion.

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 and Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	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). CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), and 10 marks for Alternative Assessment Tool (AAT).

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

be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
40%	Understand
50%	Apply
10 %	Analyze
0%	Evaluate

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	The description of the solar system, basic concepts of orbital mechanics, and space mission parameters emphasises for analysis of launch trajectory problems.
II	The fundamentals of chemical rocket propulsion, types of igniters and performance considerations for long-duration applications.
III	The working principle of solid and liquid propellant rockets and gain basic knowledge of hybrid rocket propulsion used for augmenting the thrust of an rocket engine.

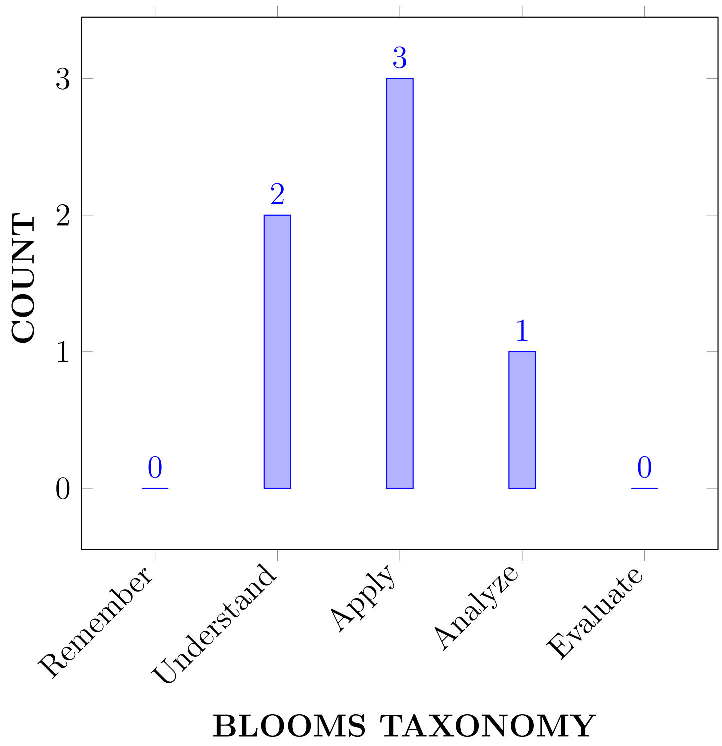
IV	The governing physics of electric propulsion, Ion propulsion and nuclear rocket thrusters used for comparison with chemical rocket propulsion.

VII COURSE OUTCOMES:

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

CO 1	**Identify** the equations of various orbits for Launch vehicle ascent trajectories.	Apply
CO 2	**Classify** the operating principles of rocket engines for determining the performance characteristics of various multistage rocket.	Analyze
CO 3	**Discuss** propellant grain design concepts implemented in solid rocket propulsion for selecting optimal grain design based on requirements.	Understand
CO 4	**Identify** various erosive burning and combution instability performance parameters for determine the burning rate and combution characteristics.	Apply
CO 5	**Compare** different propellant concepts implemented in rocket motor for identifying the optimal combinations based on particular application.	Understand
CO 6	**Make use of** the concepts of electric propulsion systems for selecting the suitable technique as per the mission requirements.	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 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		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	1	Quiz/AAT
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	2	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	Demonstrate Orbital elements, launch vehicle accent trajectories and launch vehicle performance using the **knowledge of mathematics, science and engineering fundamental.**	3
	PSO 1	**Synthesize and analyze** launch vehicle ascent trajectories problems to real world systems and provide solutions for different orbits.	1
CO 2	PO 1	Analyze the performance parameters of various rocket propulsion systems by applying the suitable engineering knowledge **mathematics, science and engineering fundamentals.**	3
	PSO 1	**Synthesize and analyze** different combustion systems for non-air breathing engines to provide thrust for the rockets	1
CO 3	PO 1	Apply the knowledge of solid propellant (**scientific principles,mathematical and engineering fundamentals**) for the preliminary design of aircraft propulsion systems.	3
	PO 2	Identify the thrust requirement (**problem identification**), define the required propellant grain parameters (**problem statement and system definition**)using the knowledge of basic performance parameters and efficiencies of different propellant grain(**Information and data collection**),developing the proprllant design(**experimental design**) and analyse complex engineering problems (**interpretation of results**)as per the mission requirements.	5
	PO 4	Use the knowledge of performance characteristics and burn rate efficiency of different propellant(**knowledge of characteristics of particular products**) in selecting the suitable grain geometer (**understanding of contexts in which engineering knowledge can be applied, (understanding use of technical literature and other information sources)** select the suitable experimental setup for propellant test **(research methods including design of experiments)**, provide solutions for characteristics of propellant **(analysis and interpretation of data, and synthesis of the information to provide valid conclusions)**	4
	PSO 2	**Focus on broad knowledge** of attributes, performance, design issues and compromises of different propellant grain for design and development of new propulsion systems(**new products**).	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 4	PO 1	Apply the knowledge of the combustion instability **scientific principles,mathematical and engineering fundamentals** to the solution of complex engineering problems.	3
	PO 2	Identify the combustion instability (**problem statement**), select the propellant grain parameter (**problem statement and system definition**) review research literature on ploblems of combusion in various burn rate by reviewing the literature **(information and data collection)**	3
	PO 4	Use the knowledge of performance characteristics and efficiency of different propellant **(knowledge of characteristics of particular products)** in selecting the suitable grain design **(understanding of contexts in which engineering knowledge can be applied, understanding use of technical literature and other information sources)** provide solutions for characteristics of propellant **(analysis and interpretation of data, and synthesis of the information to provide valid conclusions)** and incorporate the propullent in real rocket systems **(understanding of and ability to apply a systems approach to engineering problems)**	4
	PSO 2	**Focus on broad knowledge** of attributes, performance, design issues and compromises of different propellant grain for design and development of new propulsion systems(**new products**).	2
CO 5	PO 1	Recognize the various working principles, **mathematics, science and Engineering fundamentals.** of the liquid and hybrid rocket motor to identify the performance characteristics.	3
	PO 2	Identify the type of rocket propulsion **(problem identification)**, review research literature on ploblems of liquid and hybrid rocket **(information and data collection)**, and analyse complex cryogenic flow problems **(design)**meeting the mission requirements**(solution development)**	4
	PO 4	Use the knowledge of performance characteristics and efficiency of liquid and hybrid propellants**(knowledge of characteristics of particular products)** in selecting the suitable propellants **(understanding of contexts in which engineering knowledge can be applied, understanding use of technical literature and other information sources)**	2
	PSO 2	**Focus on broad knowledge** of attributes, performance, design issues liquid and hybrid rocket propulsion for design and development of new rocket propulsion systems**(new products)**.	2

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 electric propulsion techniques **mathematics, science and Engineering fundamentals.** for alternative method for chemical rocket engine	3
	PO 2	Define the mission requirement **(problem statement and system definition)** and apply the knowledge of different types of electric propulsion available **(information and data collection)** for rocket engine	2
	PO 4	Use the knowledge of characteristics of electric propulsion **(knowledge of characteristics of particular equipment)** in selecting the suitable propulsion technique **(understanding of contexts in which engineering knowledge can be applied, understanding use of technical literature and other information sources)** and	2
	PSO 2	**Extend the focus** to understand the innovative and challenges involve for design and development of electric propulsion systems	2

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	-	-	-	-	-	-	-	-	-	40	-	-
CO 2	100	-	-	-	-	-	-	-	-	-	-	-	40	-	-
CO 3	100	50	-	40	-	-	-	-	-	-	-	-	-	60	-
CO 4	100	30	-	40	-	-	-	-	-	-	-	-	-	60	-
CO 5	100	40	-	20	-	-	-	-	-	-	-	-	-	60	-
CO 6	100	20	-	20	-	-	-	-	-	-	-	-	-	60	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 $< C \leq 40\%$ – Low/ Slight

2 - 40 % $< C < 60\%$ –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 3	3	2	-	2	-	-	-	-	-	-	-	-	-	3	-
CO 4	3	1	-	2	-	-	-	-	-	-	-	-	-	3	-
CO 5	3	2	-	1	-	-	-	-	-	-	-	-	-	3	-
CO 6	3	1	-	1	-	-	-	-	-	-	-	-	-	3	-
TOTAL	18	6	-	6	-	-	-	-	-	-	-	-	2	12	-
AVERAGE	3	1.5	-	1.5	-	-	-	-	-	-	-	-	1	3	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**PRINCIPLES OF ROCKET PROPULSION**
	History of rockets, Newtons third law, orbits and space flight, types of orbits, basic orbital equations, elliptical transfer orbits, launch trajectories, the velocity increment needed for launch, the thermal rocket engine, concepts of vertical takeoff and landing, SSTO and TSTO, launch assists.
MODULE II	**FUNDAMENTALS OF ROCKET PROPULSION**
	Operating principle, Rocket equation, Specific impulse of a rocket, internal ballistics, Rocket nozzle classification, Rocket performance considerations of rockets, types of igniters, preliminary concepts in nozzle less propulsion, air augmented rockets, pulse rocket motors, static testing of rockets and instrumentation, safety considerations.
MODULE III	**SOLID ROCKET PROPULSION**
	Salient features of solid propellant rockets, selection criteria of solid propellants, estimation of solid propellant adiabatic flame temperature, propellant grain design considerations. Erosive burning in solid propellant rockets, combustion instability, strand burner and T-burner, applications and advantages of solid propellant rockets.
MODULE IV	**LIQUID AND HYBRID ROCKET PROPULSION**
	Salient features of liquid propellant rockets, selection of liquid propellants, various feed systems and injectors for liquid propellant rockets, thrust control cooling in liquid propellant rockets and the associated heat transfer problems, combustion instability in liquid propellant rockets, peculiar problems associated with operation of cryogenic engines, introduction to hybrid rocket propulsion, standard and reverse hybrid systems, combustion mechanism in hybrid propellant rockets, applications and limitations.
MODULE V	**ADVANCED PROPULSION TECHNIQUES**
	Electric rocket propulsion, types of electric propulsion techniques, Ion propulsion, Nuclear rocket, comparison of performance of these propulsion systems with chemical rocket propulsion systems, future applications of electric propulsion systems, Solar sail.

TEXTBOOKS

1. Ronald D. Flack, "Fundamentals of Jet Propulsion with Applications", Cambridge University Press, 3rd Edition, 2011.
2. George P. Sutton, Oscar Biblarz, "Rocket Propulsion Elements", Wiley India Pvt. Ltd, 7th Edition, 2010.

REFERENCE BOOKS:

1. Jack D. Mattingly, "Elements of Propulsion: Gas Turbines and Rockets", AIAA Education Series, Edition, 2006.
2. SaeedFarokhi, "Aircraft Propulsion", Wiley, 2nd Edition, 2014.
3. David R. Greatrix, "Powered Flight: The Engineering of Aerospace Propulsion", Springer, 3rd Edition , 2012.

WEB REFERENCES:

1. http://www.aero.iisc.ernet.in/page/propulsion
2. https://afreserve.com/aerospace-propulsion
3. http://ocw.mit.edu/courses/aeronautics-and-astronautics/16-50-introduction-to-propulsion-systems- spring-2012/Syllabus/

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	Presentation on OBE		
CONTENT DELIVERY (THEORY)			
1	History of rockets	CO-1	T1-2.2, 2.6
2	Newton's third law	CO-1	T1-2.2, 2.6
3	orbits and space flight, types of orbits	CO-1	R1-2.6, 2.10
4	basic orbital equations	CO-1	R1-2.6, 2.10
5	elliptical transfer orbits	CO-1	T1-3.2, 3.3
6	launch trajectories	CO-1	T1-3.2, 3.3
7	The velocity increment needed the thermal rocket engine	CO-1	T1-3.5
8	Engine overall efficiency and its impact on aircraft range and endurance	CO-1	T1-3.5

9	SSTO and TSTO	CO-1	T1-2.13, 2.14 and 2.16
10	launch assists	CO-1	T1-2.13, 2.14 and 2.16
11	Operating principle of rocket equation,	CO-2	T2-2.15
12	specific impulse of a rocket	CO-2	T2-2.15
13	rocket nozzle classification	CO-2	T1-3.9, 3.6
14	performance characteristics of rockets	CO-2	T1-3.9, 3.6
15	air augmented rockets	CO-2	R1-2.3, T2-6.1, 6.3
16	pulse rocket motors,	CO-2	R1-2.3, T2-6.1, 6.3
17	static testing of rockets and instrumentation	CO-2	T1-6.2, 6.3
18	safety considerations	CO-2	T1-2.2, 2.6
19	Background description: Classification of rocket propulsion systems	CO-3	R1-2.6, 2.10
20	Salient features of solid propellant rockets	CO-3	R1-2.6, 2.10
21	Description of solid propellant rocket motor, solid propellant grain configurations.	CO-3	T1-3.2, 3.3
22	Solid propellant rocket motor, homogeneous propellant, heterogeneous or composite propellant	CO-3	T1-3.2, 3.3
23	Different grain cross sections, propellant burning rate, combustion of solid propellants, physical and chemical processes	CO-3	T1-35
24	Types of igniters.	CO-3	T1-35
25	Erosive burning in solid propellant rockets	CO-4	T1-3.6, 3.8
26	combustion instability	CO-4	T1-3.6, 3.8
27	strand burner and T-burner	CO-4	T2:7.22
28	applications and advantages of solid propellant rockets.	CO-4	T2:7.22
29	Salient features of liquid propellant rockets	CO-5	T2:4.2
30	selection of liquid propellants	CO-5	T2:4.2
31	various feed systems and injectors for liquid propellant rockets, thrust control,	CO-5	R2, 3.0, T2:12.2
32	cooling in liquid propellant rockets and the associated heat transfer problems,	CO-5	R2, 3.0, T2:12.2
33	combustion instability in liquid propellant rockets,	CO-5	T2:11.3

34	peculiar problems associated with operation of cryogenic engines,	CO-5	R2:15.0
35	introduction to hybrid rocket propulsion, standard and reverse hybrid systems,	CO-5	R2:15.0
36	combustion process in hybrid propellant rockets, applications and limitations.	CO-5	T2:7.1
37	Electric rocket propulsion, types of electric propulsion techniques	CO-6	T2:7.1
38	Ion propulsion, Nuclear rocket	CO-6	T2:33.4 R3:19.4
39	comparison of performance of these propulsion systems with chemical rocket propulsion systems	CO-6	T1:15.0, 33.9 R3:19.4
40	future applications of electric propulsion systems, Solar sail.	CO-6	T1:15.0, 33.9 R3:19.4
PROBLEM SOLVING/ CASE STUDIES			
1	Case study of Trajectory about the target planet.	CO 1	T1, T2 R1,R2
2	Review of Equations of motion-General characteristics of motion for different orbits	CO 1	T2 2-4
3	Review of Expansions in elliptic motions	CO 1	T1, T2 R1,R2,R3
4	Case study of Orbital Elements. Relation between orbital elements and position and velocity	CO 1	T2: 3.3
5	Calculate the duration of the burn, exhaust gas velocity relative to the rocket, Calculate the specific impulse,area of the nozzle exit	CO 2	T4:7.3
6	Determine impulse provided by each stage of rocket and total propellant carried in it	CO 2	T1: 6.5
7	Stage mass ratios, Ideal velocities, propulsive efficiency, structural mass fraction of each stage, Thrust at each stages	CO 2	T2: 3.3
8	Case study of electrical rocket engines	CO 6	R2:7.3
9	Case study of ion jet propulsion system	CO 6	R4: T6.3.2
10	Case study of pulsed plasma electrical propulsion system	CO 6	T1: 4.1
11	Problems on solid propellant grain configuration	CO 3	T2:5.6
12	Problems on design of burning rate of solid propellant rocket	CO 3	R4:5.1
13	Problems on design of rocket nozzle	CO 2	T2: 5.1
14	Problems on rocket engine thrust vector control	CO 5	T2: 3.5
15	Problems on rocket combustion instability	CO 4	T1: 7.6
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	The expansions in elliptic motion, orbital elements, launch vehicle accent,orbits and space flight, types of orbits, basic orbital equations,velocity increment in thermal rocket engine trajectories	CO-1	T1-3.2, 3.3

2	Rocket systems, forces and moments acting on a rocket propulsion, Ideal rocket equation, air augmented rockets and pulse rocket motors	CO-2	T1-3.2, 3.3
3	propellant grain design consideration, combustion process in rocket engine, strand burner, the important factors that influence the burning rate of a solid propellant, selection criteria of solid propellantsAmmonium perchlorate, Double base and composite propellant. Pyrogen and Pyrotechnic igniter	CO-3	T1-3.2, 3.3
4	selection criteria of liquid propellants,combustion instability, fuel – oxidizer combination for hybrid propellant rockets, strand burner and T-burner,hybrid propellant rocket engine,liquid propellant system over solid propellant system	CO-4,5	T1-3.2, 3.3
5	Electric rocket propulsion, types of electric propulsion techniques, Ion propulsion,arc plasma rocket engine electromagnetic thrusters and solar sail powered spacecraft	CO-6	T1-3.2, 3.3
DISCUSSION OF QUESTION BANK			
1	Newton‘s third law, orbits and space flight,basic orbital equations, elliptical transfer orbits, launch trajectories, the velocity increment needed the thermal rocket engine	CO 1	R1-2.6, 2.10
2	Operating principle of rocket equation, specific impulse of a rocket, rocket nozzle classification, performance characteristics of rockets, air augmented rockets, pulse rocket motors, static testing of rockets and instrumentationEquations of motion, Introduction to chemical rocket propulsion systems.	CO 2	R1-2.3, T2-6.1, 6.3
3	selection criteria of solid propellants, propellant grain design considerations. Types of igniters and Erosive burning in solid propellant rockets, combustion instability, strand burner and T-burner, applications and advantages of solid propellant rockets	CO 3,4	R1-2.6, 2.10
4	selection of liquid propellants, various feed systems and injectors for liquid propellant rockets, thrust control, cooling in liquid propellant rockets and the associated heat transfer problems, combustion instability in liquid propellant rockets, peculiar problems associated with operation of cryogenic engines, introduction to hybrid rocket propulsion, standard and reverse hybrid systems, combustion process in hybrid propellant rockets, applications and limitations	CO 5	R2, 3.0, T2:12.2
5	Electric rocket propulsion, types of electric propulsion techniques, Ion propulsion, Nuclear rocket, comparison of performance of these propulsion systems with chemical rocket propulsion systems, future applications of electric propulsion systems, Solar sail.	CO 6	T1:15.0, 33.9 R3:19.4

Signature of Course Coordinator **HOD,AE**
Mr. A. Lakshmi Srinivas, Assistant Professor

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**ANALYSIS OF AIRCRAFT STRUCTURES**				
Course Code	AAEC15				
Program	B.Tech				
Semester	V				
Course Type	CORE				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4		
Course Coordinator	Ms. C Sushmitha, Assitant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC01	II	Engineering Mechanics
B.Tech	AAEC01	III	Mechanics of Solids
B.Tech	AAEC06	IV	Aerospace Structures

II COURSE OVERVIEW:

Analysis of Aircraft 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 a wing, fuselage, and landing gears have been introduced to analyze, design, and development of flight vehicles' structural components.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Analysis of Aircraft structures	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

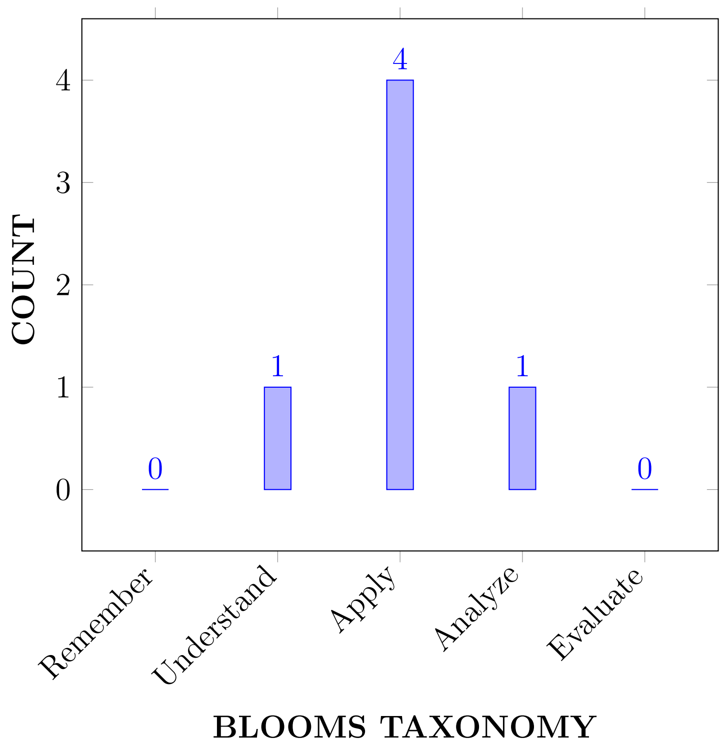
I	The application of mathematical principles on aircraft structural components and determination of deflections and stresses under various loading conditions.
II	The concepts of thin plate theory, phenomena of thin plate structural instability, analysis of bending, shear and torsion of thin walled beams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

VII COURSE OUTCOMES:

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

CO 1	**Utilize** the energy principles to aircraft structural components for interpreting minimal stress loading conditions.	Apply
CO 2	**Choose** the minimum energy principles and Fourier series solutions to thin rectangular plates subject to a given boundary conditions for predicting the stresses and strains.	Apply
CO 3	**Inspect** the deflection and twist produced in thin walled open and closed section beams under torsion loads for designing beams with minimum stresses.	Analyze
CO 4	**Develop** the elementary beam bending theory to thin walled open and closed section beams for predicting warping and torsion of aircraft structural components.	Apply
CO 5	**Illustrate** the concepts in structural idealization in transforming complex structural geometries to simple structural geometries used for interpreting the stress distribution on aircraft structures.	Understand
CO 6	**Make use of** maximum stress theories to aircraft structural components for determining failure stresses under various loading conditions.	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.	2.8	CIE/SEE/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1.6	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	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.	3	Quiz
PSO 2	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	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	Apply the **knowledge of mathematics, engineering fundamentals**, to identify different aircraft components and loads acting on aircraft components using engineering specialization to the solution of complex engineering problems	2
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems related to aircraft loads in reaching substantiated conclusions using first **principles of mathematics, natural sciences, and engineering sciences**.	3
CO 2	PO 1	Apply the concept of thin plate theory used in structural Engineering to demonstrate deflections using the **principles of Mathematics,Science and Engineering fundamentals**.	3
	PO 2	Identify various theories related to thin plates and **formulate** the complex structural engineering problems and compare the deflection curves with various boundary conditions in reaching substantiated conclusions by the **interpretation of results**	3
CO 3	PO 1	Apply the **principles of Mathematics,and Engineering** to thin walled beams subjected to different loading conditions to predict deflections in complex engineering structures.	2
	PO 2	Design a thin-walled structures with use of **Mathematics,sciences and Engineering principles** to predict the stresses in out of plane	4
CO 4	PO 1	Apply the **principles of Mathematics, Science and Engineering** to predict the stresses produced in thin walled open and closed section beams used in aerospace structures.	3
	PO 2	Identify key features involved in open and closed section thin walled beams to analyze the deflections produced due to torsion using the **principles of Mathematics,Sciences and Engineering**	4
	PSO 2	Make use of **formulation and evaluation of aircraft elastic bodies** for characterization of aero elastic phenomena.	1
CO 5	PO 1	Apply the knowledge of **Mathematics,Sciences and Engineering principles** to transform complex aircraft structures to simple geometrical structure to analyze the stresses and deflections produced due to loads.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 4	Apply the **Engineering principles** for a given complex structural geometry and use the **Mathematical principles** to reduce it to simple geometry and verify the obtain results with existing literature.	5
CO 6	PO 1	Apply the **principles of Mathematics,Science and Engineering** to determine the stresses acting on an aircraft to avoid failures.	3
	PO 2	Identify various failure theories used in aircraft structural engineering and **formulate** the suitable method to **determine** stresses, collect the data related to various components and **vallidate** it with experimental data using the first **principles of Mathematics,Science and Engineering**	5
	PSO 1	Synthesize and analyze the failure loads in the aircraft structures, with use of computer aided tools to avoid damage and prolong the life of a structure	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	2	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-		-	3	-
CO 5	3	-	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

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

XVIII SYLLABUS:

MODULE I	**FATIGUE OF AIRCRAFT STRUCTURE**
	Impact Strength: Introduction, Impact stresses due to axial, bending and torsional loads, effect of inertia. Fatigue Strength: Introduction, S-N Diagram, Low cycle fatigue, High cycle fatigue, Endurance limit, modifying factors: size effect, surface effect, Stress concentration effects, Fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading, cumulative fatigue damage.
MODULE II	**ENERGY METHODS**
	Strain Energy due to axial, bending and Torsional loads. Composite beam, Clapeyron's Three Moment Equation textbfColumns: Columns with various end conditions, Euler's Column curve, Rankine's formula, Column with initial curvature, Eccentric loading, south-well plot, Beam-column.

MODULE III	**LAMINATED AIRCRAFT COMPOSITE STRUCTURES**
	Classification and characteristics of composite materials,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.
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.
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. 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.

REFERENCE BOOKS:

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.

WEB REFERENCES:

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COURSE WEB PAGE:

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XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference 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			
1	Impact Strength:	CO1	T1:12.1
2	Impact stresses due to axial loading	CO1	T1:12.2
3	Impact stresses due to bending loading	CO1	T1:12.3
4	Impact stresses due to torsional loading	CO 1	T1:14.2 R2:4.25

5	effect of inertia	CO 1	T1:5.5 T1:5.10
6	Fatigue Strength	CO 1	T1:5.6 T2:15.2
7	S-N Diagram	CO 1	T1:5.6 T2:15.2
8	Low cycle fatigue	CO 1	T1:5.6 T2:15.2
9	High cycle fatigue	CO 1	T1:5.6 T2:15.2
10	Endurance limit,	CO 2	T2:5.6 R1:22.5
11	modifying factors	CO 2	T2:5.6 R1:22.5
12	size effect	CO 2	T1:9.1 R1:22.6
13	surface effect	CO3	T1:9.1 R1:22.6
15	Stress concentration effects	CO 3	T2:18.20 T2:11.1
16	Fluctuating stresses	CO4 3	T2:18.20 T2:11.1
17	Goodman and Soderberg relationship	CO 3	T2:18.20 T2:11.1
18	stresses due to combined loading	CO 3	T2:18.20 T2:11.1
19	cumulative fatigue damage	CO 3	T2:18.20 T2:11.1
20	Strain Energy due to axial, bending and Torsional loads.	CO 4	T1:16.1
21	Composite beam,	CO 4	T1:16.1
22	Clapeyron's Three Moment Equation	CO 4	T1:16.6
23	Columns with various end conditions	CO 4	T1:16.6
24	Euler's Column curve	CO 4	T1:16.6
25	Rankine's formula	CO 4	T1:17.1
26	Column with initial curvature,	CO 4	T2:6.4 R2:6.2
27	Eccentric loading, south-well plot, Beam-column.	CO 4	T1:18.1.2
28	Classification and characteristics of composite materials,Combinations of composite materials, Mechanical Behavior.	CO 5	T1:20.1
29	Basic terminology-laminae, laminates, Manufacture – Initial form of constituent Materials, Layup, Curing, Strength	CO 5	T1:20.2
30	stiffness Advantages, Cost Advantages, and Weight Advantages.	CO 5	T1:16.3
31	Applications- Military, Civil Aircraft, Space and Automotive	CO 5	T2:22.5
32	Elastic constants of a simple lamina, Stress–strain relationships for an orthotropic ply(macro- approach)	CO 5	T2:22.5

33	Thin-walled composite beams.	CO 5	T2:22.5
34	General aspects, Shear stress distribution at a built-in end of a closed section beam	CO6	T1:27.1
35	Thin-walled rectangular section beam subjected to torsion.	CO 6	T1:27.1
36	I-section beam subjected to torsion	CO 6	T1:27.1
37	Torsion of an arbitrary section beam	CO 6	T1:23.8 T2:19.14
38	Distributed torque loading	CO 6	T1:22.4, T2:5.18
39	Extension of the theory to allow for general systems of loading	CO 6	T1:22.4, T2:5.18
40	Moment couple (bimoment).	CO 6	T1:22.4, T2:5.18
PROBLEM SOLVING/ CASE STUDIES			
1	Numerical problems on aircraft fatigue load	CO 1	R2:7.5
2	Numerical problems on aircraft high and low cycle fatigue loads	CO 1	R2:7.5
3	Numerical problems on Endurance limit	CO 1	R2:7.5
4	Numerical problems on Stress concentration effects, Fluctuating stresses	CO 2	R2:7.5
5	Calculation of Goodman and Soderberg relationship	CO 2	R2:7.5
6	Calculating Goodman and Soderberg relationship	CO 2	R2:7.5
7	stresses due to combined loading	CO 3, CO 4	R2:7.5
8	cumulative fatigue damage	CO 3, CO 4	R2:7.5
9	Strain Energy due to axial, bending and Torsional loads.	CO 3, CO 4	R2:7.5
10	Columns with various end conditions	CO 2	R2:7.5
11	Stress–strain relationships for an orthotropic ply(macro-approach)	CO 5	R2:7.5
12	Elastic constants of a simple lamina	CO 5	R2:7.5
13	Numerical problems on Thin-walled rectangular section beam subjected to torsion.	CO 6,	R2:7.5
14	Shear stress distribution at a built-in end of a closed section beam	CO 6	R2:7.5
15	Torsion of an arbitrary section beam, Distributed torque loading,	CO 6	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Module I: Discussion on definations and terminologies related to Aircraft structural components and fatigue loadings	CO 1	R2:7.5
2	Module II: Discussion on definations and terminologies related to energy methods and beam columns.	CO 2	R2:7.5
3	Module III:Discussion on definations and terminologies related to laminated aircraft composite structures	CO 3, CO 4	R2:7.5

4	Module IV: Discussion on definations and terminologies structural and loading discontinuities- closed section beams	CO 5	R2:7.5
5	Module V:Discussion on definations and terminologies related to structural and loading discontinuities- open section beams	CO 6	R2:7.5
DISCUSSION OF QUESTION BANK			
1	Module I:Numerical problems related to fatigue aircraft structural components.	CO 1	R4:2.1
2	Module II:Numerical problems related to strain energy and impact energy methods,beam-columns.	CO 2	T4:7.3
3	Module III: Numerical problems related to Stress–strain relationships for an orthotropic ply(macro- approach)	CO 3, CO 4	R4:5.1
4	Module IV:Numerical problems related to Shear stress distribution at a built-in end of a closed section beam	CO 5	T1:7.5
5	Module V:Numerical problems related to Shear stress distribution at a built-in end of a open section beam	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,AE**
Ms. C Sushmitha, Assitant Professor

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

COURSE DESCRIPTION

Department	**Aeronautical Engineering**				
Course Title	**High Speed Aerodynamics**				
Course Code	AAEC16				
Program	B.Tech				
Semester	Five				
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. A. Rathan Babu, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AAEC08	IV	Aerodynamics

II COURSE OVERVIEW:

The primary objective of this course is to introduce the concept of high-speed aerodynamics (Compressible aerodynamics). The high-speed aerodynamics is the first course for graduate and undergraduate students in Aerospace Engineering. The precise algorithm, mathematical derivation, numerical solutions is also the primary objective of this subject. The experimental techniques and its applications are taught to meet the requirements of industry need. The course consists of a strong mathematical component in addition to the design of various concepts. 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 learning.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
High Speed 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	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
15 %	Understand
50 %	Apply
35 %	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 SEE and 05 marks for Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	SEE	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.

SEE - Online Examination
Two SEE 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 SEE 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:

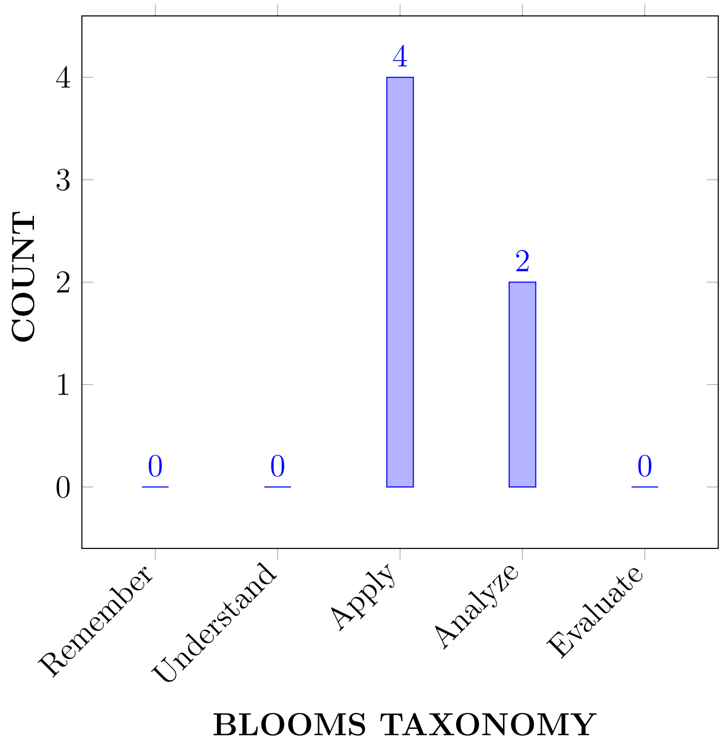
I	Basic concepts of compressible flow, governing equations of compressible flow, compressibility effect at high speeds and their importance on the design of high-speed vehicles.
II	The wave formations, propagation in supersonic flow field and their resultant effect on flow properties variations.
III	The Method of characteristics, compatibility equations and method of solutions for isentropic and non-isentropic flows.
IV	The various experimental methods and measurement techniques utilized in compressible flow regimes.

VII COURSE OUTCOMES:

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

CO 1	**Utilize** the basic concepts of gas dynamics for determining how compressibil ity affects the global and local nature of flow.	Apply
CO 2	**Construct** the equations of change in pressure, density and temperature for determining the nature of compression and expansion waves.	Apply
CO 3	**Develop** the fundamental equation for one-dimensional and quasi one-dimensional flow of compressible ideal gas.	Apply
CO 4	**Examine** the steady isentropic flow, flow with friction and flow with heat transfer for solving problems in flow through one-dimensional passage..	Analyze
CO 5	**Analyze** the airfoils at subsonic, transonic and supersonic flight conditions using the perturbed flow theory assumption for solving compressible flow over finite wing.	Analyze
CO 6	**Apply** the various optical flow visualization techniques used for capturing compressible flow fields.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

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.	2	CIA/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	2	CIA/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 technology and computer aided engineering in aeronautical systems including air traffic controls standards.	2	CIA/SEE/ AAT
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	CIA/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	**Apply** principals of mathematics to build the governing equations for compressible flows using the knowledge of **mathematics and science fundamentals.**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Recognize the importance of compressibility and continuum postulate by applying condition for function to be **analytic principles of mathematics and the Engineering knowledge.**	3
	PO 3	**Recall** the fundamental principles of fluid dynamics and aerothermodynamics for determining forces generated on the object present in high speed using the knowledge of**mathematics, science and Engineering fundamentals.**	2
	PSO 1	**Understand** the behavior of flow through constant area passage with heat addition and friction by **by science and engineering fundamentals.**	2
CO 2	PO 1	Explain various equations of flow properties jump across compression and expansion waves by applying the principles of **mathematics, science and engineering fundamentals.**	3
	PO 2	Recognize the relationship between formation of wave formation and flow boundary condition by applying the principles of **mathematics, science and Engineering fundamentals.**	3
	PO 3	**Apply** principals of mathematics to frame the energy equation for compressible flows using the knowledge of **mathematics and science fundamentals.**	2
	PO 4	Understand the given **problem statement and formulate** flow properties variation across different waves by the provided **information and data** in reaching substantiated conclusions by the interpretation of results.	2
	PSO 1	**Identify** the importance of governing equation for flow with friction and heat addition by applying the principles of **science and engineering fundamentals.**	2
CO 3	PO 1	**Build** the governing equation for quasi one dimensional and one-dimensional flows. For effective utilization by applying the principles of **mathematics, science and engineering fundamentals.**	3
	PO 2	Explain various equations of flow properties jump across compression and expansion waves by applying the principles of **mathematics, science and engineering fundamentals.**	3
	PO 3	Apply the fundamental concept of fluid mechanics to **understand** the wave formation on the wedge and concave surfaces of supersonic vehicles based on **mathematical principles and engineering fundamentals of** vibrations	2
	PO 10	Understand the given **problem statement and formulate** the governing equations of motion for supersonic vehicles from the provided **information** and substantiate with the **interpretation of** variations in the **results.**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 12	**Apply** the governing equations of compressible flows for various geometries present in supersonic flow field. Identify the limitations of different shapes for the selection of parameters, **use creativity for innovative solutions.**	2
	PSO 3	**Identify** the importance of perturbation theory on linearizing compressible flow governing equation by using the**mathematics, science and engineering fundamentals.**	2
CO 4	PO 1	**Identify** the importance of governing equation for flow with friction and heat addition by applying the principles of **science and engineering fundamentals.**	3
	PO 2	**Build** dthe linear velocity potential equation of steady irrotational isentropic compressible flow for **analyzing the given engineering problems and generate the solution.**	2
	PO 3	**Understand** the methods to solve compressible flow over two-dimensional airfoil **for innovative solutions, and understand the economic context** .	2
	PO 4	**Identify** the methods for solving (complex) **engineering problems** related flow through isentropic nozzle by applying the principles of mathematics. **mathematics.**	2
	PSO 1	**Identify** the behavior of flow through a variable cross section area passage with heat addition and friction by **by science and engineering fundamentals.**	2
CO 5	PO 1	**Identify** the importance of perturbation theory on linearizing the continuity, momentum and energy equations by using the**mathematics, science and engineering fundamentals.**	3
	PO 2	**Build** the linear velocity potential equation of steady irrotational isentropic compressible flow for **analyzing the given engineering problems and generate the solution.**	2
	PO 3	**Understand** the methods to solve compressible flow over 3D wings with winglets **for innovative solutions, and understand the economic context**	2
	PO 5	**Determine**the method of characteristics to design the De-Laval nozzle for **analyzing the given engineering problems and generate the solution.**	2
	PSO 1	**Understand**the theory of characteristics and design methodology of convergent-divergent nozzle using the **mathematics, science and engineering fundamentals.**	2
	PSO 3	**Identify** special preliminary features of wind tunnels, elementary functions of its components and their importance in **mathematics, science and engineering fundamentals.**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	PO 1	**Determine** appropriate flow visualization technique for compressible flow over high-speed aircraft component and their design by applying the principles of **mathematics, science and engineering fundamentals.**	3
	PO 2	Apply the principles of shock tubes in analyzing the supersonic aircraft components and make use of **engineering and mathematical methods** to facilitate the physical interpretation.	3
	PO 3	Understand the given **problem statement** of compressible flow over a supersonic vehicle from the provided **information and data.**	3
	PO 10	**Understand** utilization of optical flow visualization to analyses the aerodynamic characteristics of aircraft components for **design and development of new products.**	3
	PSO 1	**Identify** the importance performance characteristics of supersonic intake on the operation of gas turbine engine by applying the principles of**science and engineering fundamentals.**	2

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	5	5	-	-	-	-	-	-	-	-	-	2	-	-
CO 2	3	5	7	8	-	-	-	-	-	-	-	-	2	-	-
CO 3	3	7	5	-	-	-	-	-	-	3	-	5	-	-	2
CO 4	3	5	7	8	-	-	-	-	-	-	-	-	2	-	-
CO 5	3	5	5	-	1	-	-	-	-	-	-	5	2	-	2
CO 6	3	5	7	-	-	-	-	-	-	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	-	-
CO 2	100	50	70	80	-	-	-	-	-	-	-	-	50	-	-
CO 3	100	70	50	-	-	-	-	-	-	60	-	60	-	-	50
CO 4	100	50	70	80	-	-	-	-	-	-	-	-	50	-	-
CO 5	100	50	50	-	90	-	-	-	-	-	-	60	50	-	50
CO 6	100	50	70	-	-	-	-	-	-	60	-	-	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	-	-
CO 2	3	2	3	2	-	-	-	-	-	-	-	-	2	-	-
CO 3	3	3	2	-	-	-	-	-	-	2	-	2	-	-	2
CO 4	3	2	3	2	-	-	-	-	-	-	-	-	2	-	-
CO 5	3	2	2	-	2	-	-	-	-	-	-	2	2	-	2
CO 6	3	2	3	-	-	-	-	-	-	2	-	-	2	-	-
TOTAL	18	13	15	4	2	-	-	-	-	4	-	4	10	-	4
AVERAGE	3	2	2	2	2		-	-	-	-	-	-	2	-	2

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIA Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓	Tech talk	✓	Mini Project	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO COMPRESSIBLE FLOWS**
	Basic concepts: Introduction to compressible flow, brief review of thermodynamics and fluid mechanics, integral forms of conservation equations, differential conservation equations, continuum postulates, acoustic speed and Mach number, governing equations for compressible flows.
MODULE II	**SHOCK AND EXPANSION WAVES**
	Shocks and expansion waves: Development of governing equations for normal shock, stationery and moving normal shock waves, applications to aircrafts, supersonic wind tunnel, shock tubes, shock polars, supersonic pitot probes; oblique shocks, governing equations, reflection of shock, Prandtl-Meyer expansion flow, shock expansion method for flow over airfoil, introduction to shock wave boundary layer interaction.

MODULE III	**DIMENSIONAL AND QUASI ONE DIMENSINAL FLOW**
	Quasi one-dimensional flow: Isentropic flow in nozzles, area Mach relations, choked flow, under and over expanded nozzles, slip streamline. One dimensional flow: Flow in constant area duct with friction and heat transfer, Fanno flow and Rayleigh flow, flow tables and charts for Fanno flow and Rayleigh flow.
MODULE IV	**APPLICATIONS OF COMPRESSIBLE FLOWS AND NUMERICAL TECHNIQUES**
	Small perturbation equations for subsonic, transonic, supersonic and hypersonic flow; Experimental characteristics of airfoils in compressible flow, supercritical airfoils, area rule; Theory of characteristics, determination of the characteristic lines and compatibility equations, supersonic nozzle design using method of characteristics.
MODULE V	**EXPERIMENTAL METHODS IN COMPRESSIBLE FLOWS**
	Experimental methods: Subsonic wind tunnels, supersonic wind tunnels, shock tunnels, free-piston shock tunnel, detonation-driven shock tunnels, and expansion tubes and characteristic features, their operation and performance, flow visualization techniques for compressible flows

TEXTBOOKS

1. John D. Anderson, —Modern Compressible flow with historical perspective McGraw-Hill Education, 3rd Edition, 2002.

2. John D. Anderson, —Fundamentals of Aerodynamics, McGraw-Hill Education, 6th Edition, 2016.

REFERENCE BOOKS:

1. Ascher H. Shapiro, —The Dynamics and Thermodynamics of Compressible Fluid Flow John Wiley & Sons; Volume 1st Edition, 1977.

2. Radha Krishnan Ethirajan, —Gas Dynamics, John Wiley & Sons, 2nd edition 2010

WEB REFERENCES:

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

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	-
CONTENT DELIVERY (THEORY)			
2	Introduction to compressible flow	CO 1	T1:60
3	Brief review of thermodynamics and fluid mechanics	CO 1	T1:488-499
4	Integral forms of conservation equations, differential conservation equations	CO 1	T1:97-132

5	Continuum postulates	CO 1	T1:58
6	Acoustic speed and Mach number	CO 1	T1:560-564
7	Governing equations for compressible flows	CO 1	T1:499-501
8	Shocks and expansion waves	CO 2	T1:602-606
9	Development of governing equations for normal shock	CO 2	T1:515-557
10	Stationery and moving normal shock waves,	CO 2	T1:515-557
11	Applications to aircrafts	CO 2	T1:580-581
12	Supersonic wind tunnel, shock tubes	CO 2	T1:570-575
13	Shock polars, supersonic pitot probes	CO 2	T1:570-575
14	Oblique shocks, governing equations, reflection of shock	CO 2	T1:566-570
15	Prandtl-Meyer expansion flow	CO 2	T1:590-596
16	Shock expansion method for flow over airfoil	CO 2	T1:590-596
17	Introduction to shock wave boundary layer interaction	CO 2	T1:870
18	Quasi one dimensional flow	CO 3	T1:289
19	Isentropic flow in nozzles, area Mach relations, choked flow	CO 3	T1:626-630
20	Under and over expanded nozzles, slip streamline.	CO 3	T1:631-638
21	One dimensional flow	CO 4	R2:61
22	Flow in constant area duct with friction and heat transfer	CO 4	R2:314:321
23	Fanno flow and Rayleigh flow	CO 4	R2:302-314
24	Flow tables and charts for Fanno flow and Rayleigh flow.	CO 4	R2:302-314
25	Small perturbation	CO 5	R2:232
26	Perturbation equations for subsonic, transonic	CO 5	R2:232
27	Perturbation equations for supersonic and hypersonic flow	CO 5	R2:232
28	Experimental characteristics of airfoils in compressible flow	CO 5	R2:24
29	Supercritical airfoils,Area rule	CO 5	R2:27,12
30	Theory of characteristics	CO 5	T1:691-693
31	Determination of the characteristic lines	CO 5	T1:691-693
32	Compatibility equations	CO 5	T1:729-736

33	Supersonic nozzle design using method of characteristics	CO 5	T1:729-736
34	Experimental methods Subsonic wind tunnels	CO 6	T1:200-215
35	Supersonic wind tunnels	CO 6	T1:200-215
36	Shock tunnels	CO 6	T1:200-215
37	Free-piston shock tunnel	CO 6	T1:200-215
38	Detonation-driven shock tunnels,	CO 6	T1:200-215
39	Expansion tubes and characteristic features, their operation and performance	CO 6	T1:486
40	Flow visualization techniques for compressible flows.	CO 6	T1:486
PROBLEM SOLVING/ CASE STUDIES			
1	Compressible flow - governing equations	CO 1	T1
2	Integral forms of conservation equations	CO 1	T1
3	Downstream flow of the expansion fan	CO 2	T1
4	Normal shock wave	CO 2	T1
5	Theta-Beta-Mach relation	CO 2	T1
6	Very low speed flows of airfoils	CO 2	T1
7	Supersonic wind tunnel	CO 2	T1
8	Prandtl-Meyer expansion flow	CO 2	T1
9	Development of governing equations for normal shock	CO 2	T1
10	Stationery and moving normal shock waves,	CO 2	T1
11	Isentropic supersonic flow with a convergent divergent nozzle	CO 4	T1
12	Small perturbation , Perturbation equations for subsonic, transonic,supersonic and hypersonic flow	CO 5	T1
13	Wind tunnel model and the prototype to be flight-tested.	CO 6	T1
14	A Subsonic open-circuit wind tunnel	CO 6	T1
15	Closed circuit supersonic tunnel shock tubes	CO 6	T1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Introduction to compressible flow, brief review of thermodynamics and fluid mechanics, integral forms of conservation equations, differential conservation equations, continuum postulates, acoustic speed and Mach number, governing equations for compressible flows.	CO 1	T1
2	Shocks and expansion waves: Development of governing equations for normal shock, stationery and moving normal shock waves, applications to aircrafts, supersonic wind tunnel, shock tubes, shock polars, supersonic pitot probes; oblique shocks, governing equations, reflection of shock, Prandtl-Meyer expansion flow, shock expansion method for flow over airfoil, introduction to shock wave boundary layer interaction.	CO 2	T1

3	Quasi one-dimensional flow: Isentropic flow in nozzles, area Mach relations, choked flow, under and over expanded nozzles, slip streamline. One dimensional flow: Flow in constant area duct with friction and heat transfer, Fanno flow and Rayleigh flow, flow tables and charts for Fanno flow and Rayleigh flow.	CO 3,4	T1
4	Small perturbation equations for subsonic, transonic, supersonic and hypersonic flow; Experimental characteristics of airfoils in compressible flow, supercritical airfoils, area rule; Theory of characteristics, determination of the characteristic lines and compatibility equations, supersonic nozzle design using method of characteristics.	CO 5	T1
5	Experimental methods: Subsonic wind tunnels, supersonic wind tunnels, shock tunnels, free-piston shock tunnel, detonation-driven shock tunnels, and expansion tubes and characteristic features, their operation and performance, flow visualization techniques for compressible flows	CO 6	T1
DISCUSSION OF QUESTION BANK			
1	Introduction to compressible flows for slender and blunt bodies	CO 1	T1
2	Shock and expansion waves over wedge, cone, and wings	CO 2	T1
3	One dimensional quasi steady equation for compressible flows	CO 3,4	T1
4	Numerical schmes and techiques used in evaluting the compressible flows	CO 5	T1
5	Experimental techniques used for analyzing the compressible flows on slender bodies	CO 6	T1

Signature of Course Coordinator **HOD,AE**

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**Rocket and Missile Technology**				
Course Code	AAEC27				
Program	B.Tech				
Semester	V				
Course Type	PROFESSIONAL ELECTIVE-II				
Regulation	UG20				
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	AAEC07	IV	Aircraft Propulsion
B.Tech	AAEC08	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 Missile Technology	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

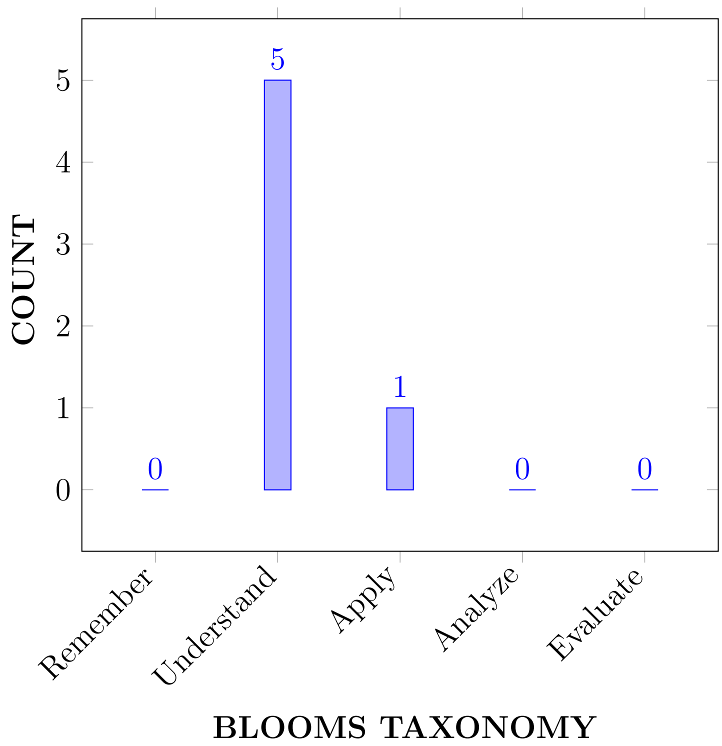
I	The fundamental concepts of various rocket propulsion systems, combustion process and forces/moments acting on the rocket under static and dynamic conditions.
II	The operating principle of guided missile, and the guidance, control and instrumentation needed to acquire the target.
III	Properties of 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	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.	3	Quiz/AAT
PSO 2	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	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	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 5	3	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 and application of rocket propulsion, rocket systems, airframe components, rocket principle and its equation, forces and moments acting on a rocket, inertial and non-inertial frames, Propulsive efficiency and performance parameters of a rocket, rocket nozzle and flow separation, Multistage of rockets, 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, propellant feed system and engine cycles for pump feed system, types of valves, injectors and applications. Liquid monopropellant and different bipropellant systems, cryogenic propellants, cooling of thrust chamber, pogo and slosh combustion instability and thrusters for control and numerical problems..

MODULE IV	**MISSILE AERODYNAMICS AND GUIDANCE SYSTEMS**
	Guided missile systems, Indian missile program, structure of the missile and its aerodynamics, aerodynamic characteristics of complete structure, wing design, warheads and fuzzes, Guidance phases during flight, standard terminologies in missile guidance, classification of guidance systems in missiles.
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

3. T V Karthikeyan, —Guided Missiles‖, Defence Scientific information and Documentation Centre, 1990.

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			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
2	Classification and application of rocket propulsion	CO 1	T2: 1.1-1.5, T1: 4.1
3	Rocket systems, airframe components	CO 5	T2: 1.1-1.5, T1: 4.1
4	rocket principle and its equation	CO 1	T2: 2.1-2.2, R1: 3.1

S.No	Topics to be covered	CO's	Reference
5	inertial and non-inertial frames, Propulsive efficiency and performance parameters of a rocket	CO 3	T2: 2.3-2.4
6	Equations of motion for three-dimensional motion through atmosphere	CO 3	T2: 3.3
7	Rocket nozzle and flow separation	CO 5	T2: 3.3
8	Multistage of rockets, numerical problems.	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
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	Guided missile systems, Indian missile program	CO 5	T1: 4.1
23	Aerodynamic characteristics of complete structure	CO 5	T1: 4.2
24	wing design, warheads and fuzzes	CO 2	T1: 4.3
25	Guidance phases during flight, standard terminologies in missile guidance	CO 2,5	T2: 5.2
26	Multistage of rockets ,Vehicle optimization techniques	CO 1	T2: 5.2
27	classification of guidance systems in missiles.	CO 1	T1: 7.2

S.No	Topics to be covered	CO's	Reference
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
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

S.No	Topics to be covered	CO's	Reference
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
DISCUSSION OF QUESTION BANK			
1	Equations of motion, Calculation of rocket performance parameters, Rocket propulsion systems, Multistage rockets	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. Aerodynamics of Missiles, Indian Missile program, Guidance law.	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	HEAT AND MASS TRANSFER				
Course Code	AAEC17				
Program	B. Tech				
Semester	V				
Course Type	Elective				
Regulation	UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. S. Srikrishnan, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEC02	III	Engineering Thermodynamics
B.Tech	AAEC03	III	Fluid Dynamics

II COURSE OVERVIEW:

Heat transfer is the flow of thermal energy due to temperature difference and the subsequent temperature distribution changes commonly measured as heat flux. This course focuses on heat transfer modes such as conduction, convection and radiation, boundary conditions, one dimensional steady and unsteady state condition, heat exchangers and mass transfer mechanisms applied to modern aero-thermal systems for designing higher thermal efficient systems. Thus there is great relevance for this course in modeling heat exchangers, heat treatment of fins and complex mechanical systems and creates a scope for further graduate studies.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Heat Transfer	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). 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.
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%	Remember
%	Understand
%	Apply
0 %	Analyze

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	The governing equations and performance relations of various modes of heat transfer using the three types of coordinate systems.
II	The concepts for validating heat transfer parameters during internal and external flows based on nondimensional numbers and convective mode heat transfer.
III	The performance and analysis of heat exchangers for real-time applications using various methods and indicators (such as LMTD and NTU etc).

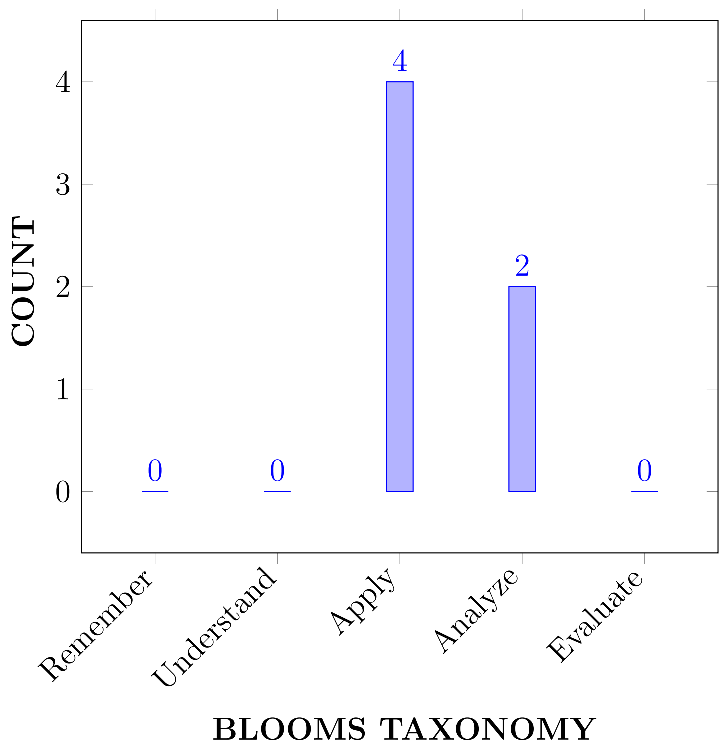
IV	The design methodologies for enhancing heat and mass transfer among a wide variety of practical engineering problems.

VII COURSE OUTCOMES:

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

CO 1	**Solve** problems involving steady state heat conduction with and without heat generation in simple geometries.	Apply
CO 2	**Make use of** the concept of Boundary layer theory for the derivation of empirical relations related to the characteristics of Boundary layer.	Apply
CO 3	**Utilize** the principles associated with convective heat transfer to formulate and solve the heat transfer coefficients for various cross section areas	Apply
CO 4	**Identify** the physical mechanisms involved in radiation heat transfer, boiling and condensation to give various correlations applied to heat exchangers, boilers, heat engines, etc.	Apply
CO 5	**Analyze** LMTD and NTU techniques for tackling real time problems with thermal analysis, simulation (mathematical model) and cost optimization of heat exchangers.	Analyze
CO 6	**Analyze** various mass transfer correlations for comparing the momentum, heat and mass transfer analogies.	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.	2	SEE/CIA
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	SEE/CIA
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	SEE/CIA
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	SEE/CIA
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	SEE/CIA
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	1	SEE/CIA

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Formulate and evaluate concepts of thermo-fluid systems to provide solutions for inter disciplinary engineering applications sustainable designs for new generation automotive systems.	3	SEE/CIA

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall (knowledge) the basic concepts of heat transfer and temperature gradients for various measures of heat transfer rate using **scientific principles** of Methodology, **mathematical principles** and **engineering fundamentals.**	3
CO 2	PO 1	Identify (knowledge) suitable mechanisms for solving the one-dimensional problems with different surfaces and geometries (fins) for which the temperature distribution and heat flow rates are calculated using **mathematical principles** and **engineering fundamentals.**	2
	PO 2	problem analysis based on first **principles of mathematics** and **engineering sciences** is essential to analyze complex engineering problems based on **data collection** which is related to steady state heat conduction with and without heat generation for **validating** the **experimental design solution**	5
CO 3	PO 2	Make use of the concept of Boundary layer theory for the **Design, Model Creation** and **Validation** of **experimental design** of heat transfer geometries by **Problem Analysis**	5

	PO 3	Understand the given **problem statement** related to their working principle and based upon type of **heat transfer process.**	2
	PSO 2	Formulate and evaluate concepts of thermo-fluid systems to **provide solutions** for inter disciplinary **engineering applications** for sustainable designs for new generation heat exchangers, boilers and heat pipes.	2
CO 4	PO 1	Recall (knowledge) the principles associated with convective heat transfer to understand the dynamics of temperature field in fluid flow using **scientific principles** of Methodology, **mathematical principles** and **engineering fundamentals.**	3
	PO 3	Understand the given **problem statement** related to their working principle and based upon type of **heat transfer process.**	2
	PO 6	Gained **Knowledge and understanding** of commercial and economic context of various convection problems will help the students to develop heat transfer equipment which is beneficial for the **society**.	2
	PO 7	Students can develop **socio economic** products in a sustainable manner by understanding the impact of the convection heat transfer solutions in **societal** and **environmental** contexts.	3
CO 5	PO 1	recall (knowledge) the physical mechanisms involved in radiation heat transfer and boiling and condensation phenomena to give various correlations using **mathematical principles** and **engineering fundamentals**.	2
	PO 3	Identify the various properties of boiling and condensation phenomena to heat engines using **Design, analytical** and **mathematical process.**	3
	PO 7	Students can develop **socio economic** products in a sustainable manner by understanding the impact of the radiation heat transfer solutions along with boiling concept in **societal** and **environmental contexts.**	3
	PSO 2	Formulate and evaluate concepts of thermo-fluid systems to **provide solutions** for inter disciplinary **engineering applications** for sustainable designs for new generation heat exchangers, boilers.	2
CO 6	PO 2	Make use of LMTD and NTU techniques used in heat exchangers and fins for the **design, model translation** and **validate** the system and **interpret** the results to get good **experimental design**	5
	PO 4	LMTD and NTU techniques are required to solve problems involving heat transfer rates in heat exchanger and fins based on **experimental data** to **understanding of and ability to apply a systems approach to engineering problems.**	2

	PO 6	**Gained Knowledge** and **understanding** of commercial and economic context of various convection problems will help the students to develop heat exchangers which are beneficial for the **society.**	2
	PO 7	Students can develop **socio economic** products in a sustainable manner by understanding the impact of the heat exchanging solutions in **societal** and **environmental** contexts.	3
	PSO 2	Formulate and evaluate concepts of thermo-fluid systems to **provide solutions** for inter disciplinary **engineering applications** for sustainable designs for new generation heat exchangers, boilers and heat pipes.	2

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	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	66.7	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	50	20	-	-	-	-	-	-	-	-	-	-	100	-
CO 4	100	-	20	-	-	40	66.7	-	-	-	-		-	-	-
CO 5	66.7	-	30	-	-	-	66.7	-	-	-	-	-	-	100	-
CO 6	-	50	-	18.1	-	40	66.7	-	-	-	-		-	100	-

XV COURSE ARTICULATION MATRIX (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	-	2	1	-	-	-	-	-	-	-	-	-	-	3	-
CO 4	3	-	1	-	-	2	3	-	-	-	-		-	-	-
CO 5	3	-	1	-	-	-	3	-	-	-	-	-	-	3	-
CO 6	-	2	-	1	-	2	3	-	-	-	-		-	3	-
TOTAL	12	6	3	1	-	4	9	-	-	-	-	-	-	9	-
AVERAGE	3	2	1	1	-	2	3	-	-	-	-	-	-	3	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO HEAT TRANSFER, CONDUCTION**
	Modes and mechanisms of heat transfer, Basic laws of heat transfer. Conduction heat transfer: Fourier rate equation, Steady, unsteady and periodic heat transfer -Initial and boundary conditions, Overall heat transfer coefficient, Electrical analogy, Critical radius of insulation, Extended surfaces (Fins) Long, Short and insulated tips. Application to error measurement of temperature. Significance of Biot and Fourier numbers, Chart solutions of transient conduction systems –concept of Functional Body.
MODULE II	**FREE AND FORCED CONVECTION**
	Free and Forced Convection – Hydrodynamic and Thermal Boundary Layer. Free and Forced Convection during external flow over Plates and Cylinders and Internal flow through tubes.
MODULE III	**PHASE CHANGE HEAT TRANSFER, HEAT EXCHANGERS**
	Film boiling, Regimes of pool boiling and flow boiling. Film wise and drop wise condensation, Nusselt‘s theory of condensation on a vertical plate. Classification of heat exchangers, overall heat transfer Coefficient and fouling factor, Concepts of LMTD and NTU methods, Problems using LMTD and NTU Methods, Application in Aero engines.

MODULE IV	RADIATION HEAT TRANSFER
	Emission characteristics, Laws of black-body radiation, Irradiation, Total and Monochromatic quantities, Heat exchange between two black bodies, concepts of shape factor, Emissivity, heat exchange between grey bodies, radiation shields, electrical analogy for radiation networks.
MODULE V	MASS TRANSFER
	Basic Concepts, Diffusion Mass Transfer, Fick's Law of Diffusion, Steady state Molecular Diffusion, Convective Mass Transfer, Momentum, Heat and Mass Transfer Analogy, Convective Mass Transfer Correlations.

TEXTBOOKS

1. Yunus A. Cengel, —Heat Transfer A Practical Approach‖, Tata McGraw hill Education (P) Ltd, New Delhi, India. 4th Edition, 2012.
2. R. C. Sachdeva, —Fundamentals of Engineering, Heat and Mass Transfer‖, New Age, New Delhi, India, 3rd Edition 2012.

REFERENCE BOOKS:

1. Holman, —Heat Transfer‖ Tata McGraw Hill education (P) Ltd, New Delhi, India. 10th Edition, 2012
2. C. P. Kothandaraman, —Heat and Mass Transfer Data Book‖, New Age International Publishers, New Delhi, India, 9th Edition 2018.
3. P. S. Ghoshdastidar, —Heat Transfer‖, Oxford University Press, 2nd Edition, 2012.
4. D. S. Kumar, —Heat and Mass Transfer‖, S.K. Kataria sons, 9th Edition 2015.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112101097/
2. . https://hyperphysics.phy-astr.gsu.edu/hbase/thermo/heatra.html

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=pages/btech-lecture-notes-iare-r18-7

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Introduction to Outcome Based Education	-	-
CONTENT DELIVERY (THEORY)			
2	Modes and mechanisms of heat transfer, Basic laws of heat transfer, Applications of heat transfer	CO 1	T2:2.3, R1:2.6
3	Fourier Equation, General heat conduction equations in Cartesian, Cylindrical and Spherical coordinates.	CO 1	T1:2.6
4	Fourier Equation, General heat conduction equations in Cartesian, Cylindrical and Spherical coordinates.	CO 1	T1:2.6

5	Simplification and forms of the field equation, steady and unsteady and periodic heat transfer.	CO 2	T2:2.7, R1:2.18
6	Transient heat transfer, Initial and boundary conditions	CO 2	T2:2.22
7	One dimensional steady state heat conduction heat transfer Homogeneous slabs	CO 3	T2:2.25
8	One dimensional steady state heat conduction heat transfer hollow cylinders	CO 2	T2:2.25
9	One dimensional steady state heat conduction heat transfer hollow spheres.	CO 2	T2:2.25
10	Overall heat transfer coefficient, Electrical analogy,	CO 2	T2:2.26 R1:2.55
11	One dimensional steady state heat conduction heat transfer	CO 3	T2:2.16 R1:2.61
12	One dimensional steady state heat conduction heat transfer: systems with variable thermal conductivity	CO 3	T2:2.16 R1:2.61
13	One dimensional steady state heat conduction heat transfer: Systems with internal heat generation.	CO 3	T2:2.16 R1:2.61
14	Extended surfaces (Fins), Long, Short and insulated tips.	CO 3	T2:2.30 R1:2.58
18	Systems with negligible internal resistance, of different geometries.	CO 3	T2:3.14 R1:4.31
20	Significance of Biot and Fourier umbers,	CO 3	T2:3.14 R1:4.33
21	Chart solutions of transient conduction systems.	CO 3	R1:4.36
22	Chart solutions of transient conduction systems with boundary conditions	CO 3	R1:4.36
23	Classification of systems based on configuration of flow and medium flow	CO 3	T2:3.18 R1:4.64
24	Classification of systems based on causation flow ,condition of flow	CO 4	T2:3.18 R1:4.64
25	Dimensional analysis as a tool for experimental investigation-Buckingham pi theorem	CO 4	T2:3.22 R1:4.67
26	Dimensional analysis for developing non-dimensional correlation for convective heat transfer.	CO 4	T2:3.22 R1:4.67
27	Dimensional analysis as a tool for experimental investigation-Buckingham pi theorem Dimensional analysis-Application for developing non-dimensional correlation for convective heat transfer.	CO 4	T2:3.22 R1:4.67
28	Dimensional analysis as a tool for experimental investigation-Buckingham pi theorem Application for developing non-dimensional correlation	CO 4	T2:3.22 R1:4.67
28	Concepts of Continuity, Momentum and Energy Equations.	CO4	T2:3.28 R1:4.67
29	External Flows Concepts of hydrodynamic and thermal boundary layer and use of empirical correlations for Flat plates.	CO 4	T2:4.2 R1:4.67
30	Critical heat flux and film boiling	CO 4	T2:4.3 R1:4.71

31	Development of Hydrodynamic and thermal boundary layer along a vertical	CO 5	T1:4.8 R2:4.68
32	Use of empirical relations for Vertical plates and pipes.	CO 5	T2:4.15 R1:5.74
33	Regimes of Pool boiling and Flow boiling, Critical heat flux, Calculations on Nucleate Boiling	CO 5	T1:4.12 R2:5.75
34	Critical heat flux and film boiling	CO 5	T1:4.8 R2:5.72
35	Condensation, Film wise and drop wise condensation, Nusselts theory of condensation on a vertical plate.	CO 5	T1:5.8 R1:5.73
36	Film condensation on vertical and horizontal cylinders using empirical correlations	CO 6	T1:5.14 R1:6.78
37	Black-body radiation, Irradiation, Total and monochromatic quantities, Laws of Planck, Wien, Kirchhoff, Lambert, Stefan and Boltzmann.	CO 6	T2:5.19 R1:6.81
38	Heat exchange between grey bodies, Concepts of shape factor	CO 6	T2:7.7 R1:7.74
39	Comparison of thermal and non -thermal processes, Classification of heat exchangers	CO 6	T1:7.8 R1:8.72
40	Overall heat transfer Coefficient and fouling factor, Concepts of LMTD and NTU methods	CO 6	T2:9.19 R1:10.814
PROBLEM SOLVING/ CASE STUDIES			
41	Problems on heat transfer modes	CO 1	T2:2.3, R1:2.6
42	Problems on Conduction	CO 1	T2:2.7, R1:2.18
43	Problems on Composite slabs	CO 1	T2:2.16 R1:2.61
44	Problems on Composite Cylinders and spheres	CO 2	T2:2.16 R1:2.61
45	Problems on Critical radious of Insulation	CO 2	R1:2.61
46	Problems on Long, Short and insulated tips Fins	CO 2	T2:2.30 R1:2.58
47	Problems on Forced Convection	CO 3	T2:3.22 R1:4.67
48	Problems on Overall heat transfer coefficient	CO 3	T1:2.6
49	Problems on forced convection	CO 4	T1:4.8 R2:4.68
50	Problems on Natural convection	CO4	T1:4.8 R2:4.7
51	Problems on configuration of flow and medium flow	CO 5	T2:4.2 R1:4.67
52	Problems on shape factor	CO 5	T2:3.28 R1:4.67
53	Problems on Critical heat flux and film boiling	CO5	T1:4.8 R2:4.68
54	Problems on LMTD and NTU methods	CO 6	T2:9.19 R1:10.814

55	Problems on heat exchangers	CO6	T2:9.19 R1:10.814
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Module: I: Introduction to Heat Transfer	CO 1	T2:2.3, R1:2.6
57	Module: II: Conduction Heat Transfer	CO 2, CO 3	T2:2.16 R1:2.61
58	Module: III: Convection Heat Transfer	CO 4	T1:4.8 R2:4.7
59	Module: IV: Radiation Heat Transfer	CO5	T2:3.28 R1:4.67
60	Module: V: Heat Exchangers and Phase change	CO 6	T2:9.19 R1:10.814
DISCUSSION OF QUESTION BANK			
61	Module: I: Introduction to Heat Transfer	CO 1	R1:2.6
62	Module: II: Conduction Heat Transfer	CO 2, CO 3	T2:2.16 R1:2.61
63	Module: III: Convection Heat Transfer	CO 4	T1:4.8 R2:4.7
64	Module: IV: Radiation Heat Transfer	CO 5	T1:4.8 R2:4.68
65	Module: V: Heat Exchangers and Phase change	CO 6	T2:9.19 R1:10.814

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

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	COMPUTER AIDED AIRCRAFT PRODCUTION DRAWING LABORATORY				
Course Code	AAEC21				
Program	B.Tech				
Semester	V	AE			
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Mr. G Rohan, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC03	II	Computer Aided Engineering Drawing

II 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.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
CAAPD 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	The principles of isometric and orthographic conversions to create CAD models using CATIA software.
II	To Create profiles and subsequently generating three dimensional entities from the generated profiles.

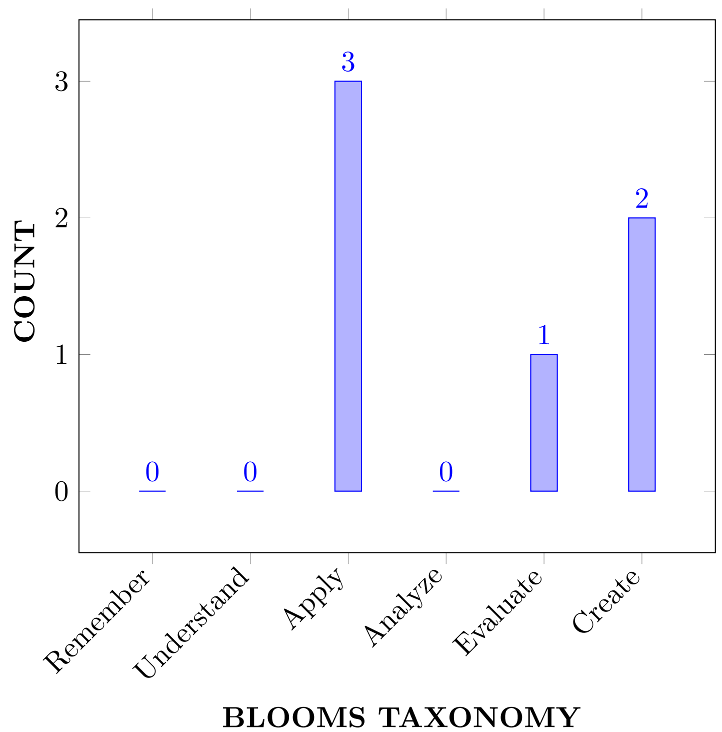
III	The fundamentals of geometric dimensioning and tolerances and representing those using designing software's.
IV	The build various aircraft parts by selecting workbenches appropriate for designing those components.

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 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	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 1	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 1	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 1	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 1	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 1	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 1	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 1
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 modeling activities 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.
WEEK III	**BOOLEAN OPERATIONS**
	Boolean Operations.
WEEK IV	**SHEET METAL DESIGN**
	Walls, Cutting and Stamping, Bending, Rolled Walls.
WEEK V	**SURFACE DESIGN**
	Surfacer, Operations, Wireframe, Replication.
WEEK VI	**ASSEMBLY**
	Product Structure Tools, Constrains.
WEEK VII	**GD and T**
	Introduction to Geometric Dimensioning and Tolerance, Weld Symbols, GD and T Symbols, Types of Tolerances, Types of views, Roughness Symbols.
WEEK VIII	**DRAFTING**
	Views, Annotations, Sheet Background.
WEEK IX	**DESIGN OF AIRCRAFT WING**
	Design of any two types of Aircraft structures.
WEEK X	**DESIGN OF FUSELAGE**
	Design of fuselage with internal components.
WEEK XI	**DESIGN OF NOSE CONE**
	Design of Nose cone structures.
WEEK XII	**DESIGN OF LANDING GEAR**
	Design of Main landing gear and nose landing gear.

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

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION

Course Title	COMPUTATIONAL STRUCTURE LABORATORY				
Course Code	AAEC22				
Program	B.Tech				
Semester	V				
Course Type	Laboratory				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Ms.D Anitha, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEC06	IV	Aerospace Structures

II 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.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
CS LABORATORY	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

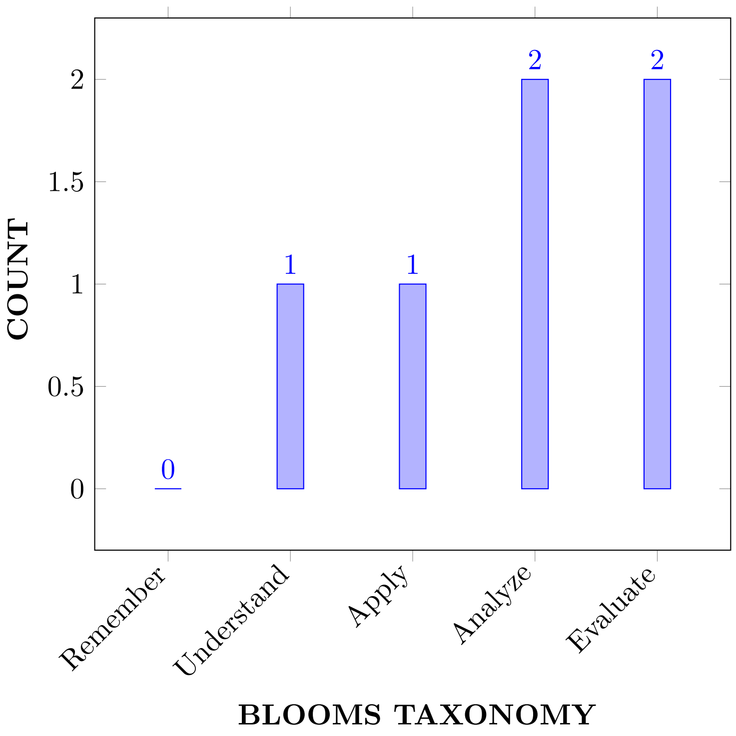
I	The theoretical basics of governing equations and convergence criteria of finite element method.
II	The commercial Finite Element packages to build Finite Element models and solve a selected range of engineering problems.
III	The approximate Finite Element Solutions for the various field problems.

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 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		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	Lab Exercises
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	Lab Exercises
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	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	3	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 MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Course	Program Outcomes								PSO'S
Out comes	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	-

XIII ASSESSMENT METHODOLOGY INDIRECT:

X	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**
Ms.D Anitha, Assistant Professor

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**FINITE ELEMENT ANALYSIS**				
Course Code	AAEC23				
Program	B.Tech				
Semester	VI				
Course Type	CORE				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. G. Shiva Krishna, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEC01	III	Mechanics of Soilds
B.Tech	AAEC06	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 Method for solving structural, thermal and dynamics problems that are too complicated to be solved by analytical methods.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Finite 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
10%	Remember
50 %	Understand
40 %	Apply
0 %	Analyze

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

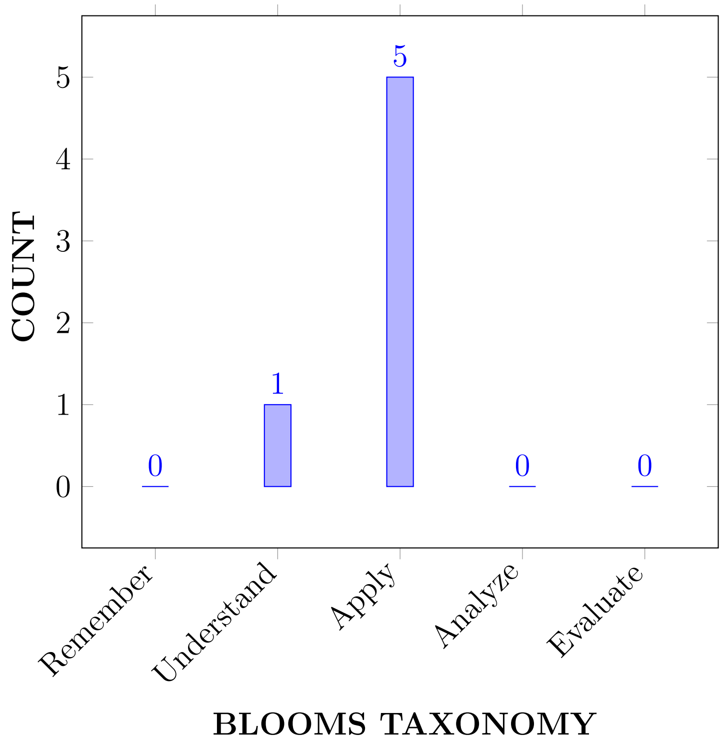
I	The theoretical basics of governing equations and convergence criteria of finite element method.
II	The commercial Finite Element packages to build Finite Element models and solve a selected range of engineering problems.
III	The approximate Finite Element Solutions for the various field problems.
IV	The application of the FEM technique to dynamic problems and validate the solutions through simulation software for real time applications.

VII COURSE OUTCOMES:

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

CO 1	**Explain** the discretization concepts and shape functions of structural members for computing displacements and stresses.	Understand
CO 2	**Make use of** shape functions of truss and beam elements for obtaining stiffness matrix and load vector to compute nodal displacement, stresses.	Apply
CO 3	**Apply** the discreet models of CST element for estimating displacement and stress.	Apply
CO 4	**Make use of** axi-symmetric modelling concepts to solids of revolution for stress approximation	Apply
CO 5	**Apply** numerical techniques to 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.

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	1	Quiz

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall 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
	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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
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	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	3	-	-	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	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	30	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	30	-	-	100	-	-	-	-	-	-	-	-	-	100

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	-	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: one dimensional analysis of slab, fin and two dimensional analysis of thin plate.
MODULE V	**DYNAMIC ANALYSIS**
	Dynamic Analysis: Formulation of finite element model, element –Mass matrices, evaluation of Eigen values and Eigen Vectors for a stepped bar, convergence requirements, mesh generation, techniques such as semi-automatic and fully automatic use of software such as ANSYS, NISA, NASTRAN etc.

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. 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‖, John Wiley and Sons, 4th Edition, 2003
4. Larry J Segerlind, "Applied Finite Element Analysis", John Wiley and Sons, 2 nd Edition, 1984.

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 Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
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
19	Treatment of boundary conditions. Estimation of load vector and stresses.	CO 3	T1:1.5 R1:2.4

S.No	Topics to be covered	CO's	Reference T1: 4.1
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
2	Problems on ritz methods using minization of potential energy approach	CO 1	T1:1.5 R1:2.4

S.No	Topics to be covered	CO's	Reference T1: 4.1
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	Module I:Discussion on definations and terminologies related to Stress strain Equilibrium	CO 1	R2:2.1
2	Module II: Discussion on definations and terminologies related to analysis of Trusses Stiffness matrix	CO 2	T2:7.3
3	Module III: Discussion on definations and terminologies related to Continuum 2-D stress analysis	CO 3, CO 4	R2:5.1
4	Module IV: Discussion on definations and terminologies related to state of heat transfer analysis	CO 5	T1:7.5

S.No	Topics to be covered	CO's	Reference T1: 4.1
5	Module V: Discussion on definations and terminologies related to dynamic analysis of finite element model	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,AE**

Mr. G. Shiva krishna

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**AIRCRAFT STABILITY AND CONTROL**				
Course Code	AAEC24				
Program	B.Tech				
Semester	VI				
Course Type	CORE				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. Yagya Dutta Dwivedi,Assoc.Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEC 09	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
✓	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
45 %	Understand
18 %	Apply
27 %	Analyze

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	The fundamental knowledge 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).

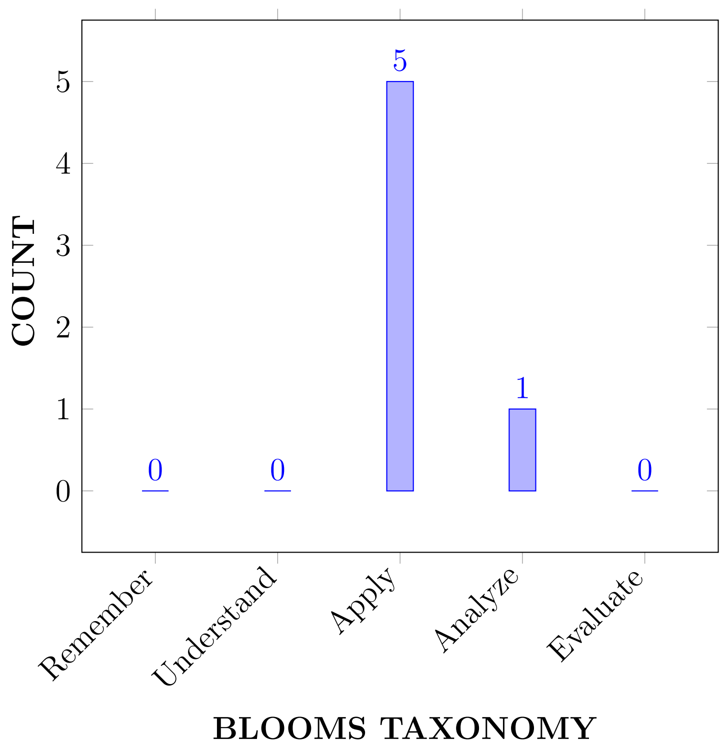
III	The methods of optimizing the aircraft equations of motion and its derivatives for aircraft dynamic stability in various flight modes.
IV	The utilization of advances of flight dynamics and control in design and development of modern airplane control systems

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	1	CIE/SEE/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	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	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	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	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 (11)**
	Aircraft axes system, Definition: Equilibrium, stability, controllability, 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 on longitudinal stability. Equations of equilibrium- stick fixed neutral point, elevator angle required to trim. Definition-static margin. Equations of motion in steady state, 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, Most forward and aft limits of CG and neutral point. Numerical.
MODULE II	**LATERAL-DIRECTIONAL STATIC STABILITY (7)**
	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 for directional static stability, aircraft component contribution for lateral-directional stability, rudder requirements. Numerical.
MODULE III	**AIRCRAFT EQUATION OF MOTION (10)**
	Description of motion of flight vehicle - systems of reference frames - earth, body, wind, stability axes system, relative merits. Euler angles, angles of attack and sideslip angle - 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 (No derivation). Relation between angular velocity components and Euler angle rates. Determination of velocities of airplane in earth axis system. Numerical.
MODULE IV	**LINEARIZATION OF EQUATIONS OF MOTION AND AERODYNAMIC FORCES AND MOMENTS DERIVATIVES (09)**
	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 (09)**
	Principle modes of motion characteristics, mode shapes and significance, time constant, un-damped 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, recovery, pilot techniques. Numerical.

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. Schmidt, L.V., "Introduction to Aircraft Flight Dynamics", AIAA Education Series, 1st Edition, 1998, ISBN A-56347-226-0.G.
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/ASC

COURSE WEB PAGE:

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
	OBE DISCUSSION		
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping.	–	
	CONTENT DELIVERY (THEORY)		
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	R1: 2.8
6	Basic concepts about airplane static stability	CO 1	T2: 2.3-2.4
7	Tail Contribution on Static Longitudinal Stability	CO 2	R1: 2.7.1
8	Neutral Point and Static Margin	CO 1	R1: 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	T2: 7.1
13	Control: Elevator	CO 1	R1: 6.3.3
14	CL trim Vs δ_e Trim and Numerical	CO 1	R1: T6.3.2
15	Trim at airplane Cruise, climb and Landing	CO 2	R1: T6.3.2
16	Trim: Maneuver	CO 2	R1: T6.3.2
17	Maneuver Point- Stick Fixed	CO 2	T1 5.5
18	Elevator required at different maneuver with numerical	CO 2	R: 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	T2:5.3
29	Vector in a Rotating Frame	CO 4	T2: 5.5
30	Euler's Angle	CO 4	T2: 5.6
30	Small perturbation theory	CO 5	T2:5.4
31	Perturbed Equations of motion- Longitudinal case	CO 5	T4: 5.5
32	Perturbed force- Fz	CO 5	T4: 11.2-11.4
33	Longitudinal Dimensional Stability Derivatives	CO 5	T1:6.1-3
34	Dynamic stability	CO 5	T1:11.14
35	Longitudinal Modes	CO 5	T1:11.2-11.4
36	Pure pitching Motion	CO 5	R1: 5.1
37	Stability Augmentation system	CO 6	T1:11.1
38	Lateral Directional Motion	CO 6	R2:15.4
39	Dynamic stability and its modes	CO 6	R2:5.4
40	Characteristics equation and stability criteria with Routh laws	CO 6	T3:7.5
PROBLEM SOLVING/ CASE STUDIES			
1	Numerical Problems Wing Contribution on Static Stability	CO 1	T3 1.1-1.5, T1: 4.1

2	Numerical Problems Stability and Tail Contribution	CO 1	T3 3.4
3	Elevator required at different maneuver with Numerical	CO 1	R2 2.8
4	Numerical on Maneuvering point	CO 1	R2: T3: 3.2
5	Numerical directional, lateral stability	CO 2	R1 :3.2
6	CL trim Vs δ_e Trim and Numerical	CO 2	T2:3.2
7	Determination of Neutral point and maneuvering point	CO 2	R1.2
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: 7.2-4
11	Problems of Dynamic Stability and revision	CO 6	T2:7.5-7
12	Frequency related Problem and solution	CO 6	T2: 7.8-9
13	Elevator power numerical	CO 3	T3: 6.4-7
14	Problems of tail/ wing combination	CO 4	T2:14.3-14.4
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, Fin-less aircraft	CO 2	T3: 2.3
3	Aircraft axis system, Forces and moments, 6-DOF, Moment of inertia, Eulers angle	CO 3, 4	R1:1.1
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: T3.3.2
3	Aircraft Equations of motion and its application.	CO 3, 4	R2: 5.1
4	Aircraft perturbed Equations of motion and application.	CO 5	T3: 11.2-11.4
5	Aircraft dynamic stability and modes.	CO 6	T1:7-4, T2:4.3

Signature of Course Coordinator **HOD,AE**
Dr. Y. D. Dwivedi Assoc.Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**
Course Title	**COMPUTATIONAL AERODYNAMICS**
Course Code	AAEC25
Program	B.Tech
Semester	VI
Course Type	CORE
Regulation	UG-20

<table>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>3</td><td>1</td><td>4</td><td>-</td><td>-</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Mr. A Rathan Babu, Assistant Professor.</td></tr>
</table>

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEC03	III	Fluid Dynamics
B.Tech	AAEC08	IV	Aerodynamics
B.Tech	AAEC16	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	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
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) and 10 marks for Alternative Assessment Tool (AAT).

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

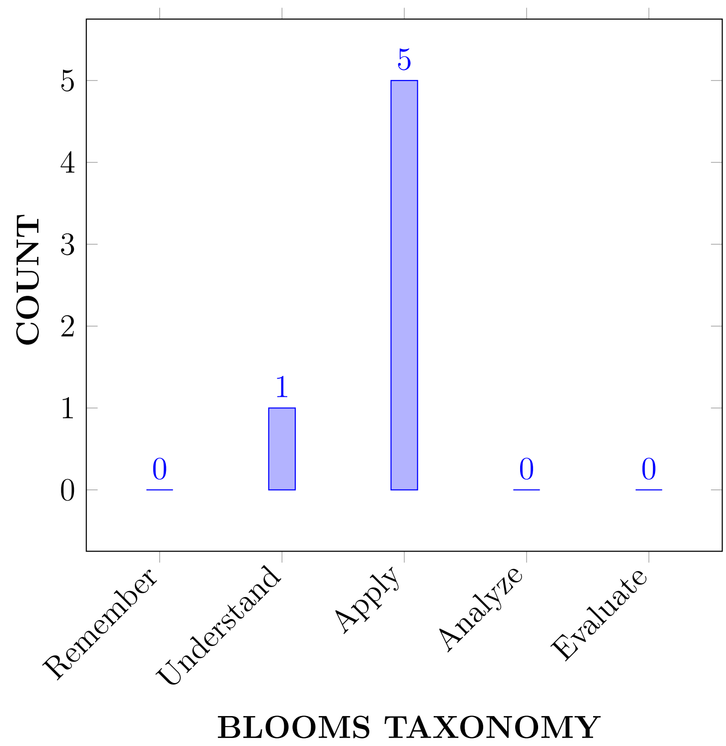
I	The concepts of grid generation techniques for simple and complex domains to model fluid flow problems.
II	The aspects of numerical discretization techniques such as finite volume and finite difference methods.
III	The mathematical modeling of different classes of partial differential equations to 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.

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	CIE/Quiz/AAT
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	CIE/Quiz/AAT
PO 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		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	Research papers/ Group discussion/ Short term courses

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	Research papers/ Group discussion/ Short term courses

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO 1	**Apply the 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
	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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	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
	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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
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):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	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:

x	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
OBE DISCUSSION			
1	Course Description on outcome Based Education (OBE) : Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	CO1,2,3,4,5,6	
CONTENT DELIVERY (THEORY)			
2	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
3	Applications of CFD in various branches of engineering.	CO 1	T2: 2.1-2.2, R1: 3.1
4	Models of fluid flow, Finite Control Volume Infinitesimal Fluid Element	CO 1	T2: 2.3-2.4
5	Substantial derivative, Physical meaning of Divergence of velocity	CO 1	T2: 2.5-2.6,

6	Continuty equation derivation and its physical significance	CO 1	T2: 3.3
7	Momentum equation derivation and its physical significance	CO 2	T2: 3.4
8	Energy equation derivation and its physical significance	CO 2	T2: 3.3
9	Physical Boundary Conditions, Significance of conservation form and their implication on CFD applications	CO 2	T2: 4.2
10	Significance of non-conservation form and their implication on CFD applications	CO 3	T2: 5.1
11	Strong and weak conservation forms	CO 3	T2: 5.2
12	Shock capturing and shock fitting approaches.	CO 1	T2: 4.5
13	Classification of quasi-linear partial differential equations by Cramer's rule method	CO 1	T1: 4.1
14	Classification of quasi-linear partial differential equations by Eigen value method	CO 3	T1: 4.2
15	General behaviour of different classes of partial differential equations.	CO 4	T1: 4.3
16	Similarity parameters: geometric, kinematic and dynamic similarity	CO 5	T2: 5.2
17	Partial different equations importance in understanding physical and CFD aspects of aerodynamic problems.	CO 5	T1 : 4.3
18	Methods of describing fluid motion:Lagragian and Eulerian approach	CO 5	T2: 5.2
19	Types of fluid flows and their mathematical formulation	CO 6	T1: 7.2
20	Different Mach numbers involving hyperbolic, parabolic and elliptic equations	CO 6	T1: 7.5
21	Dependence and range of influence for hyperbolic equations, Well-posed problems	CO 5	T1: 7.5
22	Introduction to Finite Difference approximation for first order derivatives.	CO 5	R2:7.5
23	Finite difference approximation for second order derivatives.	CO 6	R2:7.5
24	Finite difference approximation for mixed derivatives.	CO 5	R2:7.5
25	Explicit approaches, Pros and cons of higher order difference schemes	CO 5	R2:7.5
26	Implicit approaches, Pros and cons of higher order difference schemes	CO 5	T1 : 4.4
27	Difference equations- explicit and implicit approaches, Pros and cons of higher order difference schemes	CO 4	T2 : 3.3.1-3.3.4
28	Truncation and round-off errors, consistency, stability, accuracy, convergence.	CO 4	T1 : 4.5

29	Von Neumann stability analysis Physical significance of CFL stability condition.	CO 4	R1 : 6.1
30	Need for grid generation Structured grids	CO 4	R1 : 6.1.1, 6.1.3
31	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
32	Multi-block grids, C-H mesh, H-O-H mesh, overset grids	CO 4	R1 : 6.2/ R4 : 11.6
33	Adaptive grids, Unstructured grids Triangular/ tetrahedral cells, hybrid grids Quadrilateral/ hexahedra cells	CO 4	T1 : 6.5, 6.6, 6.7
34	Lax-Wendroff technique, Mac Cormack's technique Crank Nicholson technique.	CO 4	T1 : 6.8
35	Relaxation technique, aspects of numerical dissipation and dispersion.	CO 5	T1 : 6.8.2, 6.8.3 / R3 :6.6
36	Alternating Direction Implicit Technique, Pressure correction technique- application to incompressible viscous flow.	CO 5	T1 : 2.3, 2.4
37	Need for staggered grid. Philosophy of pressure correction method, Pressure correction formula	CO 5	R2:7.5
38	Numerical procedures, SIMPLE and SIMPLER algorithms, SIMPLEC and PISO algorithms	CO 4	R1 : 6.1
39	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
40	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
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	Module I:Introduction	CO 1,2,3	T2:5.10 R1:1.15
2	Module II: Mathematical behavior of partial differential equations and their impact on computational aerodynamics	CO 2,3	T2:6.1 R1:2.3
3	Module III: Basic aspects of discretization	CO 4,5	T2:7.3 R1:2.8
4	Module IV:CFD techniques	CO 5,6	T2:7.11 R1:2.32
5	Module V:Finite volume methods	CO 4,6	T2:6.3 R3:2.6.1

Signature of Course Coordinator **HOD,AE**
Mr. A Rathan Babu Assistant Professor

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**Rocket and Missile Technology**				
Course Code	AAEC27				
Program	B.Tech				
Semester	VI				
Course Type	PROFESSIONAL ELECTIVE-II				
Regulation	UG20				
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	AAEC07	IV	Aircraft Propulsion
B.Tech	AAEC08	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 Missile Technology	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

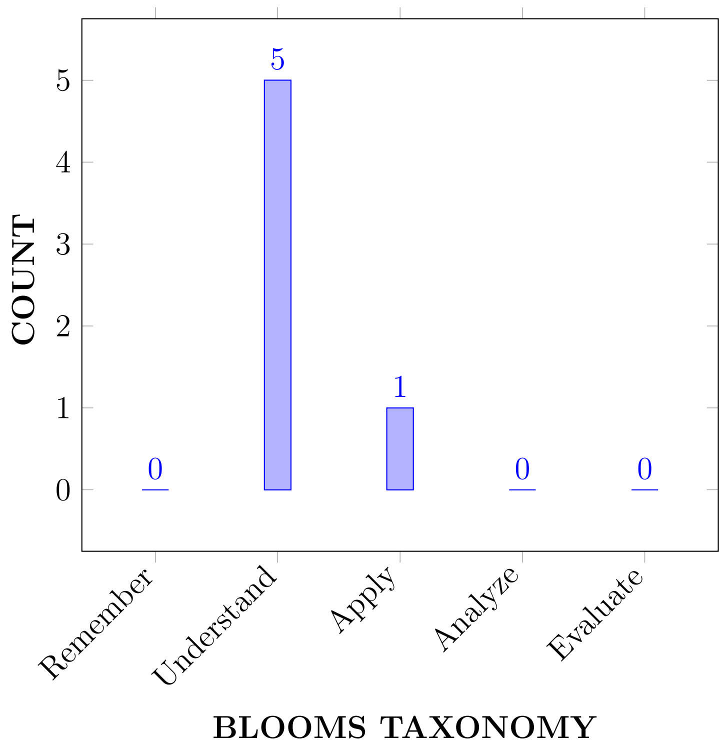
I	The fundamental concepts of various rocket propulsion systems, combustion process and forces/moments acting on the rocket under static and dynamic conditions.
II	The operating principle of guided missile, and the guidance, control and instrumentation needed to acquire the target.
III	Properties of 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	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.	3	Quiz/AAT
PSO 2	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	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	-	-	-	-	-	-	-	-	-	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 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	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	PO 1, PO 2	SEE Exams	PO 1, PO 2	Seminars	-
Term Paper		5 Minutes Video	PO1, PSO 1	Open Ended Experiments	-
Assignments		Tech Talk	PO 1, PO 2, PSO 1	Projects	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**ROCKET DYNAMICS**
	Classification and application of rocket propulsion, rocket systems, airframe components, rocket principle and its equation, forces and moments acting on a rocket, inertial and non-inertial frames, Propulsive efficiency and performance parameters of a rocket, rocket nozzle and flow separation, Multistage of rockets, 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, propellant feed system and engine cycles for pump feed system, types of valves, injectors and applications. Liquid monopropellant and different bipropellant systems, cryogenic propellants, cooling of thrust chamber, pogo and slosh combustion instability and thrusters for control and numerical problems..

MODULE IV	**MISSILE AERODYNAMICS AND GUIDANCE SYSTEMS**
	Guided missile systems, Indian missile program, structure of the missile and its aerodynamics, aerodynamic characteristics of complete structure, wing design, warheads and fuzzes, Guidance phases during flight, standard terminologies in missile guidance, classification of guidance systems in missiles.
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
3. T V Karthikeyan, —Guided Missiles‖, Defence Scientific information and Documentation Centre, 1990.

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			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
2	Classification and application of rocket propulsion	CO 1	T2: 1.1-1.5, T1: 4.1
3	Rocket systems, airframe components	CO 5	T2: 1.1-1.5, T1: 4.1
4	rocket principle and its equation	CO 1	T2: 2.1-2.2, R1: 3.1

S.No	Topics to be covered	CO's	Reference
5	inertial and non-inertial frames, Propulsive efficiency and performance parameters of a rocket	CO 3	T2: 2.3-2.4
6	Equations of motion for three-dimensional motion through atmosphere	CO 3	T2: 3.3
7	Rocket nozzle and flow separation	CO 5	T2: 3.3
8	Multistage of rockets, numerical problems.	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
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	Guided missile systems, Indian missile program	CO 5	T1: 4.1
23	Aerodynamic characteristics of complete structure	CO 5	T1: 4.2
24	wing design, warheads and fuzzes	CO 2	T1: 4.3
25	Guidance phases during flight, standard terminologies in missile guidance	CO 2,5	T2: 5.2
26	Multistage of rockets ,Vehicle optimization techniques	CO 1	T2: 5.2
27	classification of guidance systems in missiles.	CO 1	T1: 7.2

S.No	Topics to be covered	CO's	Reference
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
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

S.No	Topics to be covered	CO's	Reference
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
DISCUSSION OF QUESTION BANK			
1	Equations of motion, Calculation of rocket performance parameters, Rocket propulsion systems, Multistage rockets	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. Aerodynamics of Missiles, Indian Missile program, Guidance law.	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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**TECHNIQUES IN WIND TUNNEL TESTING**				
Course Code	AAEC36				
Program	B.Tech				
Semester	VI				
Course Type	Elective				
Regulation	IARE - UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. P K Mohanta, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEC08	IV	Aerodynamics
B.Tech	AAEC12	IV	Aerodynamics and Propulsion Laboratory
B.Tech	AAEC06	V	High Speed Aerodynamics

II COURSE OVERVIEW:

Techniques In Wind Tunnel Testing deals with development of tools employed in low speed aerodynamics and high speed aerodynamics for measuring parameters such as Pressure, Velocity and Temperature Measurements. It is multi-disciplinary subject and useful in environmental engineering, civil engineering, Automobile engineering in designing vehicle and construction and building and bridges by using low speed wind tunnel balance. 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. 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. This subject will help the students to develop the tool by using multidisciplinary techniques.

III MARKS DISTRIBUTION:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
45%	Understand
45%	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 below table

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

VI COURSE OBJECTIVES:

The students will try to learn:

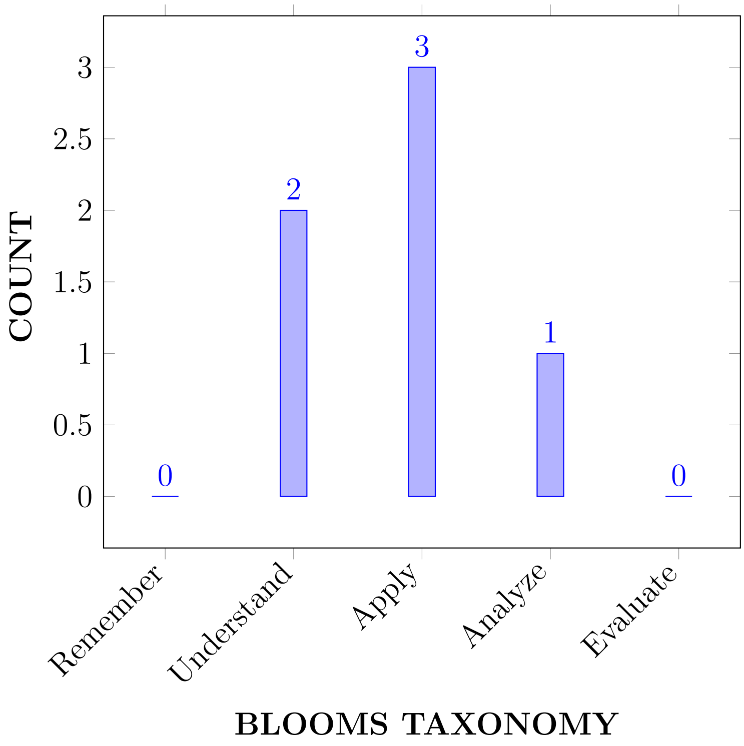
I	The constructions of low speed tunnel, high speed tunnels, transonic, supersonic and hypersonic tunnels and geometric similarity, kinematic similarity and dynamic similarity experiment techniques used for analysis aerodynamic problems.
II	The description, design constraints and loss coefficients, and 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	**Illustrate** the types of wind tunnels, Scaling Laws, Similarity parameters used for the analysis of the prototype models	Undersatand
CO 2	**Explain** the components and the percentage energy loss in the various parts of low and high-speed wind tunnels for obtaining the accurate results from the wind tunnel experiments	Understand
CO 3	**Select** the methods for the improvements of wind tunnel performance and corrective measures for obtaining accurate results	Apply
CO 4	**Identify** the various load balances used in the wind tunnels for analyzing the aerodynamic characteristics of designed prototype model.	Apply
CO 5	**Illustrate** the flow measurement devices for pressure, velocity, and temperature for a prototype model.	Apply
CO 6	**Examine** the various flow visualization techniques used in wind tunnels.for the analysis of aerodynamic and automobile engineering problems.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

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.	3	Quiz
PSO 2	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	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	Apply the **knowledge of mathematics, engineering fundamentals,**to identify different aircraft components and loads acting on aircraft components using engineering specialization to the solution of complex engineering problems.	2
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems related to aircraft loads in reaching substantiated conclusions using first **principles of mathematics, natural sciences, and engineering sciences.**	3
CO 2	PO 1	Apply the concept of thin plate theory used in structural Engineering to demonstrate deflections using the **principles of Mathematics,Science and Engineering fundamentals.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Identify various theories related to thin plates and **formulate** the complex structural engineering problems and compare the deflection curves with various boundary conditions in reaching substantiated conclusions by the **interpretation of results.**	3
CO 3	PO 1	Apply the **science** for various phenomena of fluid systems and use **principles of Mathematics,and Engineering** to thin walled beams subjected to different loading conditions to predict deflections in complex engineering structures.	2
	PO 2	Design a thin-walled structures with use of **Mathematics,sciences and Engineering** to predict the stresses in out of plane	4
CO 4	PO 1	Apply the(**principles of Mathematics, Science and Engineering**)to predict the stresses produced in thin walled open and closed section beams used in aerospace structures.	3
	PO 2	Identify key features involved in open and closed section thin walled beams to analyze the deflections produced due to torsion using the **principles of Mathematics,Sciences and Engineering**	4
	PSO 2	Make use of **formulation and evaluation of aircraft elastic bodies**for characterization of aero elastic phenomena.	1
CO 5	PO 1	Apply the knowledge of **Mathematics,Sciences and Engineering principles**to transform complex aircraft structures to simple geometrical structure to analyze the stresses and deflections produced due to loads.	3
	PO 4	Apply the **Engineering principles** for a given complex structural geometry and use the **Mathematical principles** to reduce it to simple geometry and verify the obtain results with existing literature.	5
CO 6	PO 1	Apply the **principles of Mathematics,Science and Engineering** to determine the stresses acting on an aircraft to avoid failures.	3
	PO 2	Identify various failure theories used in aircraft structural engineering and **ormulate** the suitable method to **determine**stresses, collect the data related to various components and **vallidate**it with experimental data using the first **principles of Mathematics,Science and Engineering.**	5
	PSO 1	Synthesize and analyze the failure loads in the aircraft structures, with use of computer aided tools to avoid damage and prolong the life of a structure	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	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	-		-	-	-	-	-	-		-	3	-
CO 5	3	-	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-		3	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	30	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	30	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.7	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	10	-	-		-	-	-	-	-	-	-	-	100	-
CO 5	100	-	-	66.7	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	30	-	-		-	-	-	-	-	-	-	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 $<C<$ 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	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 5	3	-	-	3	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	1	-	-	-	-	-	-	-	-	-	-	3	-	-
Total	18	5	-	3	-	-	-	-	-	-	-	-	3	3	-
AVERAGE	3	1	-	3	-	-	-	-	-	-	-	-	3	3	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**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 and 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 and Strain gauge types, null displacement methods and 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 AND 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 holes 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. Jewel B Barlow, William H Rae Jr. and Alan Pope, "Low Speed Wind Tunnel Testing", John Wiley and Sons Inc, Re-Print, 1999.
2. Alan Pope, Kennith L Goin, "High Speed Wind Tunnel Testing", John Wiley and Sons, 1965.

REFERENCE BOOKS:

1. Gorlin S M and Slezinger II, Wind tunnels and Their Instrumentations, NASA publications, Translated version, 1966 .
2. Jorge C Lerner and Ulfilas Boldes, Wind Tunnels and Experimental Fluid Dynamics research, InTech, 1st Edition, 2011.

WEB REFERENCES:

COURSE WEB PAGE:

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
2	Introduction and need of experimental test	CO 1	T1:1.1
3	Forms of aerodynamic experiments, observations, measurement objectives	CO 1	T1: 1.1
4	History: Wright Brothers wind tunnel, model testing, Wind tunnel principles	CO 1	T1:12.3
5	Scaling laws, scale parameters, Geometric similarity, kinematic similarity dynamic similarity	CO 1	T1:14.2 R2:4.25
6	Transonic, supersonic and Hyper-sonic tunnels	CO 1	T1:5.6 T2:15.2 T1:5.6 T2:15.2
7	Shock tubes, Special Wind tunnels	CO 1	T1:5.6 T2:15.2 T1:5.6 T2:15.2

S.No	Topics to be covered	CO's	Reference
8	Wind tunnels for industrial and various applications apart from aerospace requirements	CO 1	T1:5.6 T2:15.2
9	Low speed wind tunnels, principal components	CO 1	T1:5.6 T2:15.2
10	Function, description, design requirements	CO 2	T2:5.6 R1:22.5
11	constraints and loss coefficients	CO 2	T2:5.6 R1:22.5
12	Wind tunnel performance flow quality, power losses	CO 2	T1:9.1 R1:22.6
13	Wind tunnel corrections, Sources of inaccuracies: buoyancy	CO 3	T1:9.1 R1:22.6
14	Solid blockage, wake blockages	CO 3	T2:18.20 T2:11.1
15	Streamline curvature causes, estimation and correction	CO 3	T2:18.20 T2:11.1
16	Load measurement: low speed wind tunnel balances, mechanical	CO 3	T2:18.20 T2:11.1
17	Strain gauge types, null displacement methods and strain method	CO 3	T2:18.20 T2:11.1
18	SSensitivity, weigh beams, steel yard type and current balance type	CO 3	T2:18.20 T2:11.1
19	Model support three-point wire support, three-point strut support	CO 3	T2:18.20 T2:11.1
20	Platform balance, yoke balance	CO 4	T1:16.1
21	Strain gauge, 3-component strain gauge balance	CO 4	T1:16.1
22	3-component strain gauge balance, Description, Application	CO 4	T1:16.6
23	Pressure: static pressure, surface pressure orifice, static probes	CO 4	T1:16.6
24	Pitot probe for total pressure, static pressure and flow angularity	CO 4	T1:17.1
25	Pressure sensitive paints, steady and unsteady pressure measurement	CO 4	T1:17.1
26	Various types of pressure probes and transducers, errors in pressure measurement	CO 4	T2:6.4 R2:6.2
27	Temperature: measurement of temperature using thermo couples, resistance thermometers	CO 4	T1:18.1.2
28	Temperature sensitive paints and liquid crystals. Velocity: measurement of airspeed	CO 5	T1:20.1
29	Basic terminology-laminae, laminates, Manufacture – Initial form of constituent Materials, Layup, Curing, Strength	CO 5	T1:20.2
30	Mach number from pressure measurements, flow direction, boundary layer profile using pitot static probe	CO 5	T1:16.3
31	5 hole probe yaw meter, total head rake, Hot wire anemometry	CO 5	T2:22.5
32	Laser Doppler anemometry and working principle	CO 5	T2:22.5
33	observation, recording, interpretation of imagery	CO 5	T2:22.5

S.No	Topics to be covered	CO's	Reference
34	Flow visualization: necessity, streamlines, streak lines, path lines, time lines	CO 6	T1:27.1
35	Tufts, china clay, oil film	CO 6	T1:27.1
36	Smoke, hydrogen bubble	CO 6	T1:27.1
37	Optical methods: density and refractive index, schlieren system	CO 6	T1:23.8 T2:19.14
38	Convex lenses, concave mirrors, shadow graph, interferometry	CO 6	T1:22.4, T2:5.18
39	Interferometry, working principle, description, setting up, operation	CO 6	T1:22.4, T2:5.18
40	Relative merits and applications.	CO 6	T1:22.4, T2:5.18
PROBLEM SOLVING/ CASE STUDIES			
1	Different Types of Low speed wind tunnel	CO 1	R2:7.5
2	Different types of high-speed wind tunnel	CO 1	R2:7.5
3	Kinematic, dynamic, geometric similarities	CO 1	R2:7.5
4	Test section blockage ratio	CO 2	R2:7.5
5	Energy Gyration	CO 2	R2:7.5
6	SLoads and forces measured in platform-type balance	CO 3	R2:7.5
7	Loads are forces measured in Yoke-type balance	CO 3	R2:7.5
8	Balance calibration	CO 4	R2:7.5
9	Pitot static tube, u tube manometer.	CO 4	R2:7.5
10	particle Image velocimetry	CO 4	R2:7.5
11	Air speed measurements	CO 5	R2:7.5
12	Flow visualization techniques used in wind tunnel	CO 5	R2:7.5
13	Components of Shadow graph system.	CO 6	R2:7.5
14	Components of schlieren system	CO 6	R2:7.5
15	Merits and demerits of flow visualization techniques	CO 6	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Module I: Fundamentals of Experiments in Aerodynamics	CO 1	R2:7.5
2	Module II: Wind Tunnel Experimentation Considerations	CO 2	R2:7.5
3	Module III:Wind Tunnel Balance	CO 3,4	R2:7.5
4	Module IV:Pressure, Velocity and Temperature Measurements	CO 5	R2:7.5
5	Module V:Flow Visualization Techniques	CO 6	R2:7.5
DISCUSSION OF QUESTION BANK			
1	Module I: Numericals on Fundamentals of Experiments in Aerodynamics.	CO 1	R2:2.1
2	Module II:Numerical problems related to Wind Tunnel Experimentation Considerations.	CO 2	T2:7.3
3	Module III: Numerical problems related to Wind Tunnel Balance.	CO 3,4	R2:5.1

S.No	Topics to be covered	CO's	Reference
4	Module IV:Numerical problems related to Pressure, Velocity and Temperature Measurements	CO 5	T1:7.5
5	Module V:Numerical problems related to Flow Visualization Techniques	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,AE**
Dr. P. K. Mohanta, Professor

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**ELEMENTS OF MECHANICAL ENGINEERING**				
Course Code	AMEC35				
Program	B.Tech				
Semester	VI				
Course Type	Open Elective				
Regulation	IARE -UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	–	–
Course Coordinator	Mr. D. Atchuta Ramacharyulu, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEC01	III	Mechanics of Solids

II COURSE OVERVIEW:

Understand about the working, functions and applications of equipment are used in daily life. Identify the broad context of Mechanical engineering problems, including describing the problem conditions and identifying possible contributing factors. Understand the fundamental elements of Mechanical engineering systems, system components and processes, with a good understanding of associated safety, quality, schedule and cost considerations. Employ mathematics, science, and computing techniques in a systematic, comprehensive, and Rigorous manner to support the study and solution of Mechanical engineering problems.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Elements of Mechanical Engineering	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

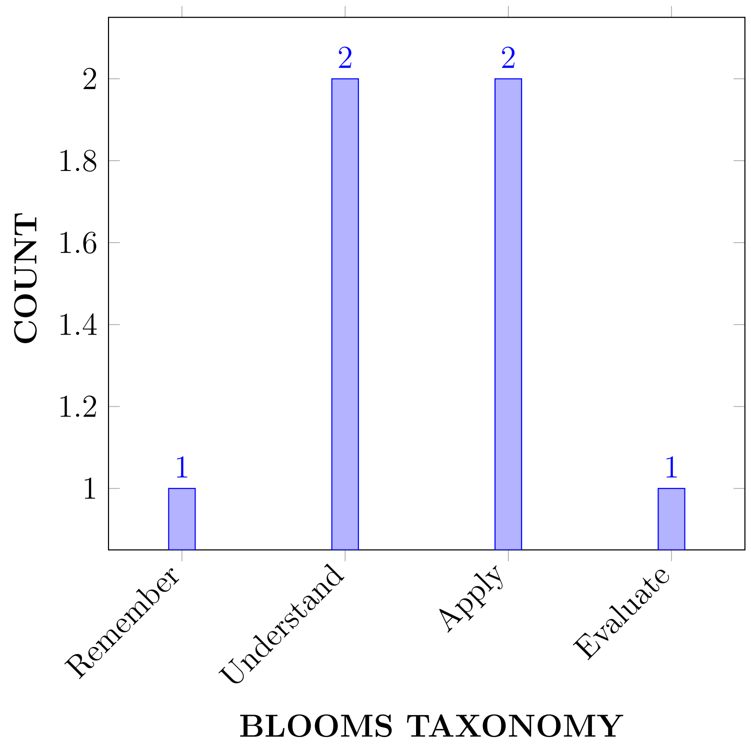
I	Familiarize with fundamental of mechanical systems.
II	Understand and appreciate the significance of mechanical engineering in different fields of engineering.
III	The various permanent and temporary joints in engineering applications subjected to various loading conditions.
IV	Understanding the application and usage of various engineering materials

VII COURSE OUTCOMES:

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

CO1	**Define** Gas laws, Boyle's law, Charle's law, gas constant, relation between Cp and Cv, various non-flow processes .like constant volume processes, constant pressure process, isothermal process, adiabatic process, polytropic process	Remember
CO2	**Understand** knowledge of formation of steam and use of steam table for identifying the various parameters at given conditions and apply to steam power plant.	Understand
CO3	**Explain** the working principle of Internal combustion engines and classification of 2-stroke engines and 4-stroke.	Understand
CO4	**Demonstrate** the working of pumps and air compressors and explain the refrigeration, types of refrigeration and air conditioning.	Apply
CO5	**Illustrate** the concepts various metals cutting machines for lathe describe various driving mechanisms of lathe.	Apply
CO6	**Select** engineering materials, their properties, manufacturing methods for encountered in engineering practice.	Analyse

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/CIA/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	SEE/CIA/AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	SEE/CIA/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.	3	Research papers / Industry exposure
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	Research papers / Industry exposure

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Explain the importance of design process and theories failues solving through the scientific principles of **mathematics** and **science.**	2
CO 2	PO 1	Identify suitable permanent joints (Rivets, Welds) in engineering applications by applying the principles of **mathematics** and **engineering fundamentals.**	2
	PO 3	**Design Procedures** of **Riveted and Welded joint problems** with **various real time applications.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 1	**Formulate** and **evaluate** engineering concepts of joints design to provide solutions for **various applications.**	3
CO 3	PO 1	Classify the different types of keys employed to various applications by applying the principles of **mathematics, sciece** and **engineering fundamentals.**	3
	PO 2	Apply the procedure of various loading on different cotter joints for **analyze** and **deriving related equations** from the provided information and substantiate with **interpretation** of **variations in the results**	4
CO 4	PO 1	Develop the theory, phenomena of Knucle joint for engineering applications by applying the principles of **mathematics, science** and **engineering fundamentals** to perform high efficiency.	3
	PO 3	**Design solutions** of **Knuckle joint problems** and **various loading conditions of each components** for different applications. .	4
	PSO 1	**Formulate** and **evaluate** engineering concepts of design to provide solutions for technology aspects in digital manufacturing.	2
CO 5	PO 1	Select the suitable shafts and couplings for numeraous engineering applications by applying the principles of **mathematics, science** and **engineering fundamentals** of design of machine elements.	3
	PO 3	**Design procedures** of **shafts** and **different strength conditions of** for various applications.	4
	PSO 1	**Formulate** and **evaluate** engineering concepts of shaft design to provide solutions for numerous applications.	2
	PSO 3	Make use of various **design tools** for**higher studies**in the field of design.	2
CO 6	PO 1	**Explain** the working principles of various springs and applying the principles of **mathematics, science** and **engineering fundamentals.** for derive the stress and deflection equations for helical and torsion springs	3
	PO 2	Determine the given **spring problem statement** and**formulate** the deflection and energy storing capability for deriving related equations from the provided information and **interpretation** of **results.**	4
	PSO 1	**Formulate** and **evaluate** engineering concepts of torsion and helical springs design to provide solutions for technology aspects in digital manufacturing.	2
	PSO 3	Make use of various **design tools** for**higher studies**in the field of design.	2

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	-	3	-	-	-	-	-	-	-	-	-	3	-	-
CO 3	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	4	-		-	-	-	-	-	-		2	-	-
CO 5	3	-	4	-	-	-	-	-	-	-	-	-	2	-	2
CO 6	3	4	-	-	-	-	-	-	-	-	-		2	-	2
TOTAL	16	8	11	-	-	-	-	-	-	-	-	-	9	-	4
AVERAGE	2.66	4	3.66	-	-	-	-	-	-	-	-	-	2.25	-	2

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	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 ENERGY SYSTEMS**
	Introduction: Prime movers and its types, concept of force, pressure, energy, work, power, system, heat, temperature, specific heat capacity, change of state, path, process, cycle, internal energy, enthalpy, statement of zeroth law and first law; Energy: Introduction and application, of energy sources like fossil fuels, nuclear fuels, hydels, solar, wind, and bio-fuels, environment issues like global warming and ozone depletion; Properties of gases: Gas laws, Boyle‘s law, Charle‘s law, gas constant, relation between Cp and Cv, various non-flow processes like constant volume processes, constant pressure process, isothermal process, adiabatic process, poly-tropic process.
MODULE II	**STEAM TURBINES, HYDRAULIC MACHINES**
	Properties of steam: Steam formation, types of steam enthalpy, specific volume, internal volume, internal energy and dryness fraction of steam, use of steam tables, calorimeters; Heat engine: Heat engine cycle and heat engine, working substances, classification of heat engines, description and thermal efficiency of Carnot, Rankin, Otto cycle, diesel cycles; Steam boilers: Introduction, Cochran, Lancashire, Babcock, and Wilcox boiler, functioning of different mountings and accessories.
MODULE III	**INTERNAL COMBUSTION ENGINES, REFRIGERATION AND AIR- CONDITIONING**
	Internal combustion engines: Introduction, classification, engine details, four stroke, two stroke cycle, petrol engine, diesel engine, indicated power, brake power, efficiencies; Pumps: Types, operation of reciprocating. rotary, centrifugal pumps, priming. Air compressors: Types, operation of reciprocating, rotary air compressors, significance of multi- staging; Refrigeration and air-conditioning: Refrigerant, vapor compression refrigeration system, vapor absorption refrigeration system, domestic refrigerator, window and split air conditioners.

MODULE IV	**MACHINE TOOLS AND AUTOMATION**
	Machine tools and automation machine tools operation: Turning, facing , knurling, thread cutting, taper turning by swiveling the compound rest, drilling, boring, reaming, tapping, counter sinking, counter boring, plane milling, end milling, slot milling; Robotic and automation: Introduction, classification based on robot configuration, polar, cylindrical, cartesian, coordinate and spherical, application, advantages and advantages; Automation: Definition, types, fixed, programmable and flexible automation, NC/CNC machines, basic elements with simple block diagrams, advantages and disadvantages.
MODULE V	**ENGINEERING MATERIALS, JOINING PROCESS**
	Engineering materials and joining processes: Types, applications of ferrous metals, non-ferrous metals, alloys; Composites: Introduction, definition, classification and application (Automobile and Air Craft).

TEXTBOOKS

1. V. K. Manglik, "Elements of Mechanical Engineering", Prentice Hall, 1st Edition, 2013.
2. Mikell P. Groover, "Automation, Production Systems and CIM", Prentice Hall, 4th Edition, 2015.

REFERENCE BOOKS:

1. S. Trymbaka Murthy, "A Text Book of Elements of Mechanical Engineering", University Press, 4th Edition, 2006.
2. K. P. Roy, S. K. HajraChoudary, Nirjhar Roy, "Element of Mechanical Engineering", Media Promoters & Publishers, 7th Edition, 2012.
3. Pravin Kumar, "Basic Mechanical Engineering", Pearson, 1st Edition, 2013.

WEB REFERENCES:

1. http://nptel.ac.in/courses/Webcourse contents/IIT % 20 Kharagpur/Machine % 20design1/New index1.html
2. http://nptel.ac.in/downloads/112105125/
3. http:/alljntuworld.in/download/design machine members 1 dmm 1materials notes/
4. http:/scoopworld.in/2015/03/design of machine members dmm mech.html

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Discuss on Outcome Based Education		
CONTENT DELIVERY (THEORY)			
2	Introduction, General considerations in the design	CO 1	R4:1.5
3	Identify Engineering Materials and their properties. Tolerances and fits BIS codes of steels.	CO 1	T1:3.1 R3:3.16

4	temperature, specific heat capacity	CO 1	T1:7.59
5	Explain zeroth, first and existing laws	CO 1	T2:5.11
6	Explain Factor of safety, Design for strength and rigidity, preferred numbers	CO 1	T2:7.3 R3:3.21
7	Introduction and application, of energy sources like fossil fuels, nuclear fuels,	CO 1	T1:7.63 R3:6.11
8	hydels, solar, wind, and bio-fuels, environment issues like global warming and ozone depletion;	CO 1	T1:7.89 R4:6.4
9	Explain Goodman's life – Soderberg's line. Solutions of problems on various types of loading.	CO 1	T1:7.9 R3:6.20
10	Compare Fasteners methods	CO 2	T1:11.2 R3:11.6
11	Explanation about Lap and but joints and various parameters involved in design of riveted joints.	CO 2	T1:9.2 R3:9.8
12	Properties of gases: Gas laws, Boyle's law, Charle's law, gas constant, relation between Cp and Cv	CO 2	T1:9.5 R3:9.14
13	Analyze Eccentrically loaded riveted joints. Problems in design of riveted joints.	CO 2	T2:8.3 R4:9.21
14	various non-flow processes like constant volume processes, constant pressure process, isothermal process	CO 2	T1:106 R4:10.17
15	adiabatic process, poly-tropic process.	CO 3	T1:11.9 R4:11.16
16	Pumps: Types, operation of reciprocating. rotary, centrifugal pumps, priming.	CO 3	T2:11.5 R4:11.10
17	Air compressors: Types, operation of reciprocating, rotary air compressors, significance of multi- staging;	CO 3	T2:11.9 R1:11.12
18	Refrigeration and air-conditioning: Refrigerant, vapor compression refrigeration system	CO 3	T2:11.21 R1:11.7
19	vapor absorption refrigeration system, domestic refrigerator, window and split air conditioners.	CO 4	T1:12.1
20	Properties of steam: Steam formation	CO 7	T1:12.15 R3:12.7
21	types of steam enthalpy, specific volume, internal volume	CO 4	T2:9.9 R3:13.8
22	internal energy and dryness fraction of steam, use of steam tables, calorimeters;	CO 4	T1:12:10 R3:12.4
23	Heat engine: Heat engine cycle and heat engine, working substances	CO 4	T1:12.16
24	classification of heat engines, and different cycles;	CO 4	T2:15.1 R3:14.16
25	Steam boilers: Introduction, Cochran, Lancashire, Babcock, and Wilcox boiler,	CO 4	T2:15.2. R2: 12.6
26	functioning of different mountings and accessories.	CO 4	T2:9.24 R2: 12.8
27	Machine tools operation and automation	CO 4	T2:9.30
28	Machining Processes - Turning, facing , knurling, thread cutting	CO 4	T2:9.30

29	Taper turning by swiveling the compound rest,	CO 5	T1:13.2 R3:14.6
30	Drilling, boring, reaming, tapping, counter sinking,	CO 5	T1:13.8
31	counter boring, plane milling, end milling, slot milling	CO5	R3:14.11
32	Robotic and automation: Introduction, classification based on robot configuration, advantages and dis advantages;	CO 5	T1:13.9 R3:14:13
33	Automation: Definition, types, fixed, programmable and flexible automation, NC/CNC machines,	CO 6	T2:16.2 R3:23.8
34	Basic elements with simple block diagrams, advantages and disadvantages.	CO 6	T2:10.3 R4:23.18
35	Engineering materials and joining processes:	CO 6	T2:10.5
36	Types,applications of ferrous metals, non-ferrous metals, alloys	CO 6	T2:10.10
37	Composites: Introduction to composites.	CO 6	T1:10.15
38	Composites: Definitions related to composites.	CO 6	T1:10.15
39	Classification of composites.	CO 6	T2:10.21
40	Applications of composites in Automobile and Air Craft.	CO 6	T2:10.21
PROBLEM SOLVING/ CASE STUDIES			
41	Problems on temperature, specific heat capacity	CO 1	R2:7.5
42	Problems on zeroth law and first law	CO 1	R2:7.5
43	Problems on factor of safety, design for strength and rigidity	CO 1	R2:7.5
44	Problem on Gas Laws	CO 2	R2:7.5
45	Problem on internal energy	CO 2	R2:7.5
46	Problem on Carnot and Rankine cycle	CO 2	R2:7.5
47	Problem on indicated power,brake power and efficiencies	CO 3	R2:7.5
48	Problem on air compressors	CO 3	R2:7.5
49	Problem on refrigeration and air conditioning	CO 3	R2:7.5
50	Problem machine tools speed and depth	CO 4	R2:7.5
51	Problem on polar, cylendrical and cartesian coordinates	CO 5	R2:7.5
52	Problem on CNC and NC machines paramaeters	CO 5	R2:7.5
53	Problem solving for Engineering Materials	CO 6	R2:7.5
54	Problem solving for Joining Process	CO 6	R2:7.5
55	Problem solving on composite materials	CO 6	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Introduction to Energy Systems	CO 1,2, 3	R4:2.1
57	Steam Turbines Hydraulic Machines	CO 1,2, 3	R4:2.1
58	IC Engines, RAC	CO 1,2, 3	R4:2.1
59	Machine Tools and Automation	CO 1,2, 3	R4:2.1
60	Engineering Materials and Joining Process	CO 1,2, 3	R4:2.1

DISCUSSION OF QUESTION BANK			
61	Introduction to energy systems	CO 1	R4:3.2
62	Steam Turbines Hydraulic Machines	CO 2,	T4:7.3
63	Internal Combustion Engine, Refrigeration and air conditioning	CO 3,4	R4:5.1
64	Machine Tools and Automation	CO 5	T1:7.5
65	Engineering Materials and Joining Process	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,ME**

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**Computational Aerodynamics Laboratory**				
Course Code	AAEC32				
Program	B.Tech				
Semester	VI	AE			
Course Type	Core				
Regulation	IARE - UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Dr. Bodavula Aslesha, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	**Course Code**	**Semester**	**Prerequisites**
B.Tech	AAEB03	IV	Aerodynamics

II 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.

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
-	-	-	-	-	-

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.

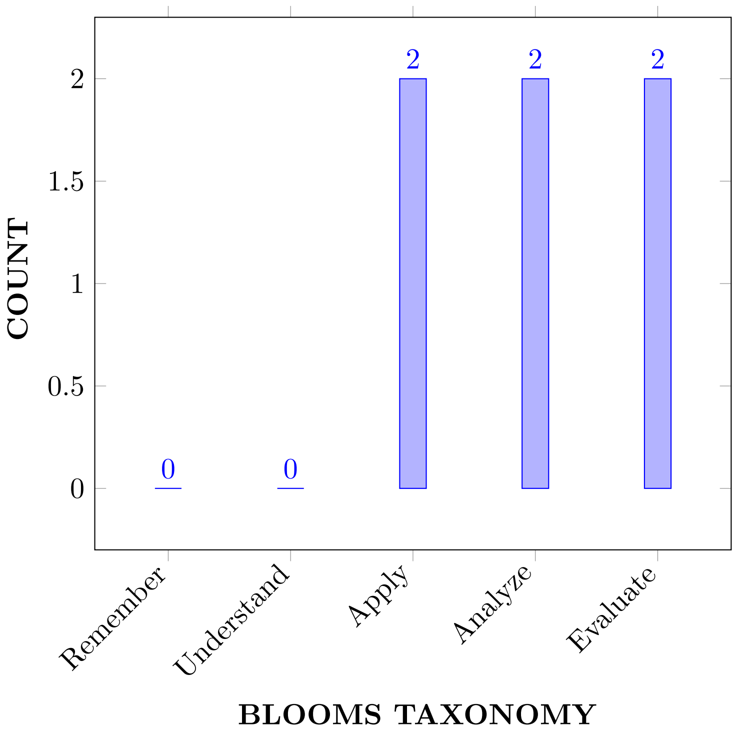
II	The aspects of numerical discretization techniques such as finite volume and finite difference methods.
III	The mathematical modeling of different classes of partial differential equations to show their impact on computational fluid dynamics.
IV	The characteristics of different turbulence models and 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

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 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	-	-	-	-	-	-	-	-	-	2
CO 2	3	2	3	2	3	-	-	-	-	-	-	-	-	-	2
CO 3	3	2	2	3	3	-	-	-	-	-	-	-	-	-	2
CO 4	3	2	2	3	3	-	-	-	-	-	-	-		-	3
CO 5	3	2	3	2	3	-	-	-	-	-	-	-	-	-	3
CO 6	3	2	2	3	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**
	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 ANSYS CFX**
	Introduction to ANSYS CFX, 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.

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.	CO 1, CO 2, CO3	R1: 2.3
2	Introduction to ANSYS CFX.	CO 2, CO 3	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 6	R3: 2.22
6	Flow over a circular cylinder.	CO 3, CO 5	R2: 2.25
7	Flow over a cambered aerofoil.	CO 5, CO6	R3: 2.55
8	Flow over a symmetric aerofoil.	CO 5, CO6	R2: 2.3
9	Flow over wedge.	CO 4, CO 5, CO 6	R1: 2.6
10	Flow over a cone.	CO 3,CO 4, CO 6	R2: 2.8
11	Code development.	CO 1, CO 2, CO 6	R1:2.18
12	Code development.	CO 1, CO 6	R4:2.22

XVI 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**
Dr. Bodavula Aslesha, Assistant Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	Computer Aided Manufacturing (CAM) Laboratory				
Course Code	AAEC33				
Program	B.Tech				
Semester	VI				
Course Type	Laboratory				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Ms. G Sravanthi, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC02	II	Computer Aided Engineering Drawing
B.Tech	AAEC13	IV	Aircraft Production Technology Laboratory

II COURSE OVERVIEW:

Computer-aided manufacturing (CAM) is an application technology that uses computer software and machinery to facilitate and automate manufacturing processes. Overview of CNC machines, component identification, safety features and precautions, setting home positions, offsets and works settings, part programming with G codes, program execution, controlling dimensional accuracy and surface finish.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Computer Aided Manufacturing (CAM) Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

Component	**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. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

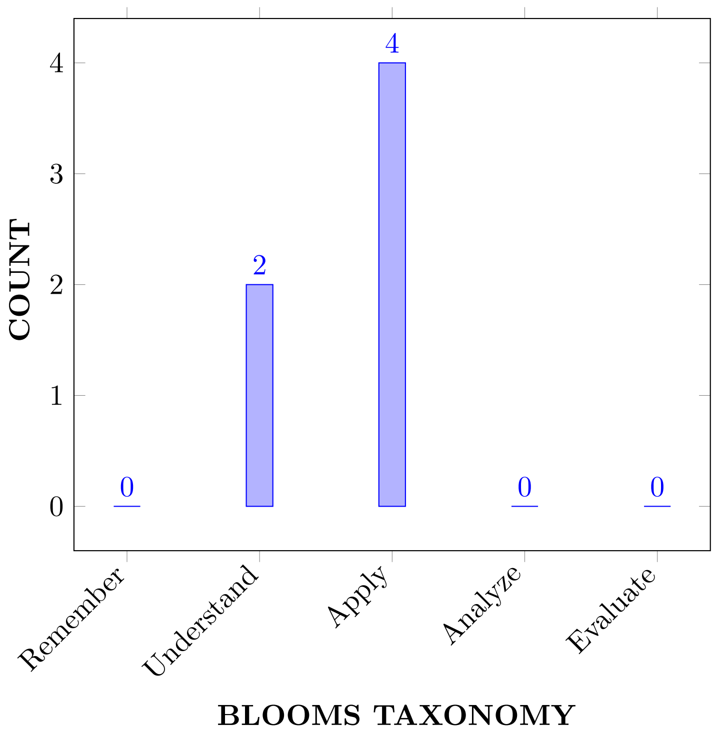
I	The various fields of engineering where these tools can be effectively used to improve the output of a product.
II	How the tools are used in industries by solving some real time problems.
III	Various stages of product development and their management.
IV	The programming and operating skills for computer numerical control (CNC) machines.

VII COURSE OUTCOMES:

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

CO 1	**Outline** various computer Numeric Control systems for suitability and application of CNC machine	Understand
CO 2	**Recognise** various standard machine tools and Numeric Codes for manufacturing machine parts by turning machines.	Understand
CO 3	**Develop** a numeric code for manufacturing machine components by milling machine.	Apply
CO 4	**Make use of** G and M codes for drilling operation on machine components using milling machine.	Apply
CO 5	**Investigate** tapping, slotting and cylindrical grinding by using CNC for manufacturing aircraft components.	Apply
CO 6	**Utilize** laser cutting and electric discharge machine for cutting and drilling of aerofoil profile.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises

PO2	**Problem 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
PO3	**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,SEE
PO5	**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

3 = High; 2 = Medium; 1 = Low

X MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES			
	PO 1	PO 2	PO 3	PO5
CO 1	3	-	-	1
CO 2	3	1	-	2
CO 3	1	2	3	1
CO 4	2	2	3	1
CO 5	1	-	3	2
CO 6	1	2	1	3

XI ASSESSMENT METHODOLOGY DIRECT:

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

XII ASSESSMENT METHODOLOGY INDIRECT:

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

XIII SYLLABUS:

WEEK I	**INTRODUCTION TO COMPUTER NUMERICAL CONTROL**
	Numerical control, functions of a machine tool, concept of numerical control, historical development, definition, advantages of CNC machine tools. Features of CNC, machine control MODULE (MCU) for CNC, classification of CNC machine tools. Features of CNC, machine control MODULE (MCU) for CNC, classification of CNC machine tools.
WEEK II	**CNC PLAIN TURNING**
	To perform the Plain Turning operation using CNC turning machine.
WEEK III	**CNC STEP TURNING**
	To perform Step turning operation using CNC turning machine.
WEEK IV	**GROOVING AND THREADING**
	To perform grooving and threading operation using CNC turning machine.
WEEK V	**DRILLING AND BORING**
	To perform drilling and boring operation using CNC turning machine.
WEEK VI	**CNC MILLING : PLAIN MILLING AND STEP MILLING**
	To perform plain milling and step milling operation using CNC milling machine.
WEEK VII	**DRILLING OPERATION**
	To perform drilling operation using CNC milling machine.
WEEK VIII	**PROFILE MILLING AND HELICAL MILLING**
	To perform profile milling and helical milling operation using CNC milling machine.
WEEK IX	**TAPPING AND SLOTTING**
	To perform tapping and slotting operation using CNC milling machine.
WEEK X	**CNC CYLINDRICAL GRINDING**
	To perform cylindrical grinding operation using CNC cylindrical grinding machine.
WEEK XI	**LASER CUTTING**
	To perform aerofoil profile cutting using Laser cutting machine.
WEEK XII	**RAPID DRILLING**
	To perform rapid drilling using Electrical Discharge machine.

TEXTBOOKS

1. Kundra T. K., Rao P. N. and Tewari M. K., ―Numerical Control and Computer Aided Manufacturing‖, Tata McGraw-Hill, 1st Edition, 1999.

2. Groover M.P., ―Automation, Production Systems and Computer Integrated Manufacturing.‖, Prentice Hall, 1st Edition, 1989.

3. Elanchezhian C, Selwyn Sunder T, Shanmuga Sundar G., ―Computer Aided Manufacturing‖, Laxmi Publications, New Delhi, 1st Edition, 2006.

4. Rao P N., ―CAD/CAM Principles and Applications‖, Tata McGraw-Hill, 1st Edition, 2006.

REFERENCE BOOKS:

1. FANUC and SIEMENS part programming manuals.
2. James D. Meadows, —Geometric Dimensioning and Tolerancing, CRC Press, 1st Edition, 1995.

XIV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Numerical control, concept of numerical control, historical development, definition,functions of a machine tool, advantages of CNC machine tools. Features of CNC, machine control MODULE (MCU) for CNC, classification of CNC machine tools. Features of CNC, machine control MODULE (MCU) for CNC, classification of CNC machine tools	CO1	T1,T2
2	To perform the Plain Turning operation using CNC turning machine.	CO1,CO2	T2,R1
3	To perform Step turning operation using CNC turning machine.	CO2	T2,R1
4	To perform grooving and threading operation using CNC turning machine.	CO2	T2,R1
5	To perform drilling and boring operation using CNC turning machine.	CO2	T3,R1
6	To perform plain milling and step milling operation using CNC milling machine.	CO3	T3
7	To perform drilling operation using CNC milling machine.	CO4	T2,R1
8	To perform profile milling and helical milling operation using CNC milling machine.	CO4	T4,R1
9	To perform tapping and slotting operation using CNC milling machine.	CO5	T3,R1
10	To perform cylindrical grinding operation using CNC cylindrical grinding machine.	CO5	T2,R1
11	To perform aerofoil profile cutting using Laser cutting machine.	CO6	T4,R1
12	To perform rapid drilling using Electrical Discharge machine.	CO6	T2,R1

XV EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	To generate NC Code for manufacturing aircraft components.
2	To create air frame structures using Laser cutting machine.
3	Design and development of Propeller blade in CNC machines

Signature of Course Coordinator **HOD,AE**
Ms. G Sravanthi, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**AUTOMATIC CONTROL OF AIRCRAFT**				
Course Code	AAEC52				
Program	B.Tech				
Semester	VIII				
Course Type	Professional Elective -VI				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. Ch Sai Krishna, Assistant Profesor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEC09	IV	Flight Mechanics
B.Tech	AAEC24	VI	Aircraft Stability and Control

II 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.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Automatic Control of Aircraft	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	x	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). 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
40 %	Apply
10 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

<table>
<tr><th colspan="2">Component</th><th>Marks</th><th>Total Marks</th></tr>
<tr><td rowspan="4">CIA</td><td>Continuous Internal Examination – 1 (Mid-term)</td><td>10</td><td rowspan="4">30</td></tr>
<tr><td>Continuous Internal Examination – 2 (Mid-term)</td><td>10</td></tr>
<tr><td>AAT-1</td><td>5</td></tr>
<tr><td>AAT-2</td><td>5</td></tr>
<tr><td>SEE</td><td>Semester End Examination (SEE)</td><td>70</td><td>70</td></tr>
<tr><td colspan="3">Total Marks</td><td>100</td></tr>
</table>

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Tech-talk	Quiz
50%	50%

VI COURSE OBJECTIVES:

The students will try to learn:

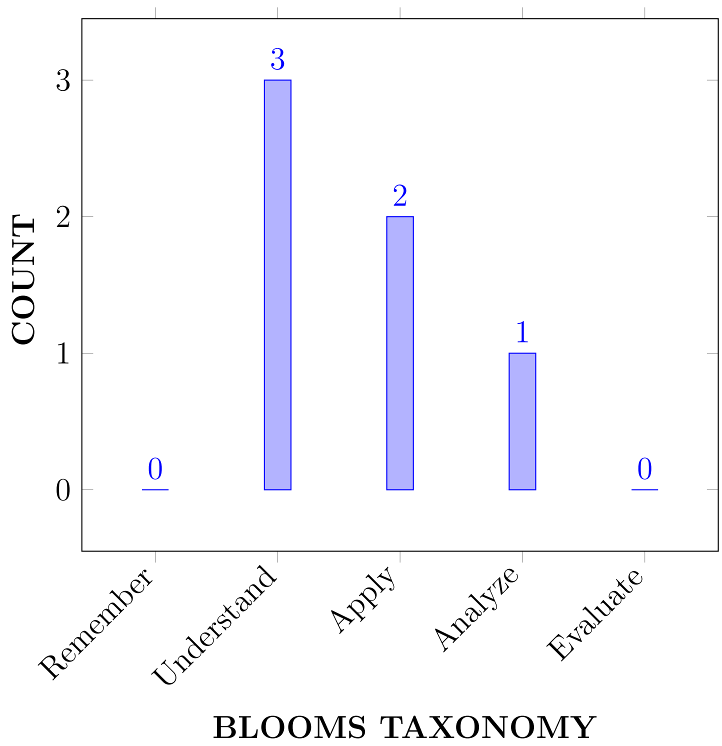
I	The guidance and control of aircraft and explain different augmentation system and concepts
II	The different auto pilot systems, flight path stabilization and automatic flare control.
III	The fly by wire flight control systems and different flight control law design using back stepping algorithm.
IV	The operating principles and design of guidance laws, launch vehicle and mission requirements.

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.	Understand
CO 2	**Demonstrate** the automatic flight control system under different types of flight conditions for assessing the stability and control of an airplane.	Understand
CO 3	**Examine** the automatic gain schedule concept for airplane automatic control by plotting the required curve of the flight vehicle.	Apply
CO 4	**Apply** the concept of displacement autopilots and orientation control in longitudinal motion with its elements for 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.	Understand
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.	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
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PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
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PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/CIE/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	SEE/CIE/AAT
PO 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		Strength	Proficiency Assessed by
PSO 2	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	2	Research papers / Group discussion / Short term courses
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	Research papers / Industry exposure

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	
CO 3	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	-	-	-	-	-	-	-	-		-	✓	-
CO 5	✓	-	-	✓	-	-	-	-	-	-	-	-	-	✓	-
CO 6	✓	✓	-	-	-	-	-	-	-	-	-		-	-	✓

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	**Recollect (knowledge)** the basic concept of static stability and to an extent appreciate (understand) the importance of longitudinal, lateral and directional modes of stability by applying the principles 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	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	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	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	Program Outcomes/ No. of Key Competencies Matched												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	6	-	5	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	7	-	-	-	-	-	-	-	-	-		-	2	-
CO 5	2	-	-	5	-	-	-	-	-	-	-	-	-	2	-
CO 6	3	5	-	-	-	-	-	-	-	-	-		-	-	1

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	100	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	60	-	50	-	-	-	-	-	-	-	-	-	-	-
CO 4	67	70	-	-	-	-	-	-	-	-	-		-	67	-
CO 5	67	-	-	50	-	-	-	-	-	-	-	-	-	67	-
CO 6	100	50	-	-	-	-	-	-	-	-	-		-	-	34

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

2 - $40\ \% < C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	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

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	Quiz	✓	Open Ended Experiments	-
Assignments	-				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

x	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION**
	Introduction to 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 & Lewis F.L, —Aircraft control & simulation, John Wiley Sons, New York, 1992.

REFERENCE BOOKS:

1. Garnel. P. & 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 & Automatic Control, McGraw Hill, 1st Edition 1989.

WEB REFERENCES:

1. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16...aircraft.../lecture-16
2. www.fsd.mw.tum.de/research/flight-control/
3. nptel.ac.in/courses/101108056/

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		
CONTENT DELIVERY (THEORY)			
2	Basic introduction to guidance and control.	CO 1	T2: 1.1-1.5, T1: 4.1
3	Definition and terms of different types of guidance.	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	R3: 2.8
6	Types of guidance system- Active verses passive homing guidance	CO 1	T2: 2.3-2.4
7	Command guidance system	CO 1	R3: 2.7.1
8	Need for automatic flight control systems	CO 1	R3: 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	T3: 7.1
13	Displacement Autopilot	CO 1	R3: 6.3.3

14	C_L trim Vs δ_e Trim and Numerical	CO 1	R3: T3.3.2
15	Pitch orientation control system	CO 2	R3: T3.3.2
16	Trim: Maneuver	CO 2	R3: T6.3.2
17	Maneuver Point- Stick Fixed	CO 2	T1 5.5
18	Acceleration control system	CO 2	R3: 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	R3: 4.2.1
22	Hinge moment and hinge derivative	CO 2	R3: 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	T3: 11.1-11.2
32	Introduction to Fly-by-wire flight control systems	CO 5	T3: 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, T3:14.4
35	Primary control laws, Normal laws	CO 5	T1:11.2-11.4, T3:14.3
36	Alternate laws, Direct laws	CO 5	R3:15.3.1
37	Redundancy and failure survival m	CO 6	T1:11.1, T3:14.3-14.4
38	Digital implementation	CO 6	R3:15.4
39	Fly-by-light flight control of airplane	CO 6	R3:15.3.1
40	Fly by Optics control of airplane	CO 6	T3:14.3-14.4
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	R3: 2.8
4	Development of Flight augmentation system- a review	CO 2	R3: T3.3.2
5	Numerical problems related to guidance system	CO 2	R3: T3.3.2
6	Basic gain scheduling system and its application and modern development in this area.	CO 2	R3: T6.3.2
7	Determination of Neutral point and maneuvering point	CO 3	R3:5.2

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	T3: 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	T3:14.3-14.4
14	Problems of control law related to automatic control of aircraft.	CO 6	T3:14.3-14.4
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	R3:5.1, 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	Introduction	CO 1	R4:2.1
2	Augmentation Systems	CO 2	T4:7.3
3	Longitudinal Autopilot	CO 3,4	R4:5.1
4	Lateral Autopilot	CO 5	T1:7.5
5	Fly by Wire Flight Control	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,AE**
Mr. Ch. Sai Krishna

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	AERONAUTICAL ENGINEERING				
Course Title	AVIONICS AND INSTRUMENTATION				
Course Code	AAEC50				
Program	B.Tech				
Semester	VII				
Course Type	Elective-V				
Regulation	UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr.K Arun Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEC24	VI	Aircraft Stability and Control

II 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

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Avionics And Instrumentation	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
20%	Remember
30%	Understand
40 %	Apply
10 %	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

Tech-talk	Concept Video
50%	50%

VI COURSE OBJECTIVES:

The students will try to learn:

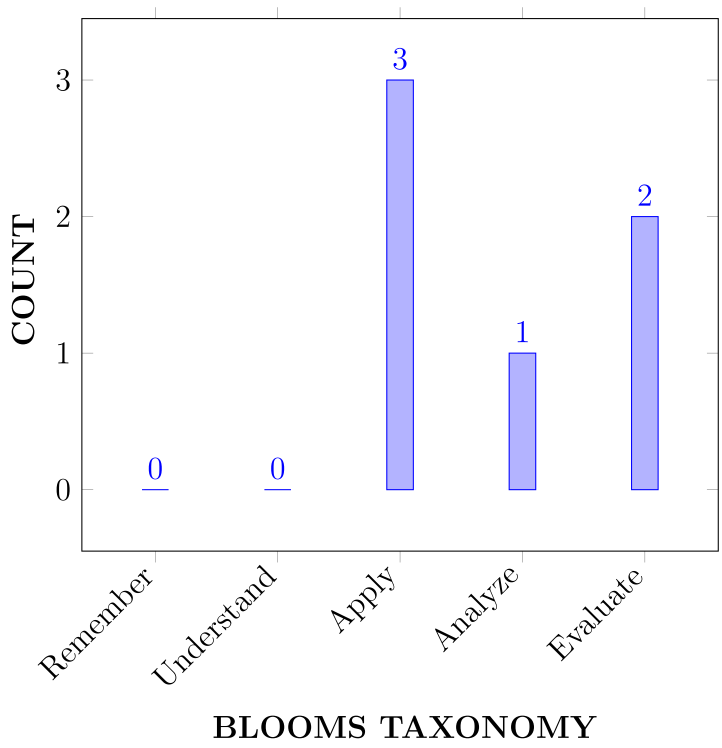
I	The principles of sensors, radars, radio communication and navigation systems and their application.
II	The Concept of microelectronic devices along with their evolution and applications, with the emphasis on digital data buses.
III	The advances in modern avionics systems, and their application in military and civil aircrafts.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Make use of** various electronic instrument and avionics systems used for the design of modem aircraft.	Apply
CO 2	**Analyze** the fundamental principles of various types of sensors for monitoring the parameters in an aircraft.	Analyze
CO 3	**Choose** the working principles of various flight instruments in flight deck for monitoring the status of the flight in one integrated display.	Evaluate
CO 4	**Develop** the basic principle and various types of navigation systems for providing accurate position of a moving aircraft relative to the earth.	Apply
CO 5	**Make use of** the concept of various navigational aids that guide the pilot for landing the aircraft safely on a runway.	Apply
CO 6	**Choose** the working principle of different sensors, radars, transmitters and magnetometers for determination of dipole moment, position and attitude.	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/SEE/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	CIE/SEE/AAT
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	CIE/SEE/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/SEE/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM 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	CIE/SEE
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	2	CIE/SEE

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	✓	-	-	-	-		✓	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	✓	-	✓	-	-	-	-	-	-	✓	-
CO 4	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	✓	✓	-	-	✓	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	-	-	✓	-	-	-	-	-	-		-	-	-

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** to classify various microelectronic devices, processors, memory devices	3
	PO 2	**Identify the problem statement** (data bus systems), select the appropriate Integrated modular avionics architectures (information and data collection) suitable to mission requirement	2
	PO 7	Analyze the performance parameters of Automatic direction finding,distance measuring equipment to **Understand the impact of the professional Engineering solutions in societal and Environmental contexts**	2
	PSO 1	**Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering** in aeronautical systems including air traffic controls standards	2
CO 2	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** and Advanced flight deck display system architectures.	3
	PO 2	Analyze the performance parameters of Automatic direction finding,distance measuring equipment using **first principles of Mathematics and engineering sciences.**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 3	PO 1	Identify various Avionic and mission system interface, navigation and flight management **using principles of mathematics, science, and engineering fundamentals.**	3
	PO 5	Identify various Avionic and mission system interface, navigation and flight management **using modern Engineering and IT tools**	1
	PO 7	Identify various Avionic and mission system interface, navigation and flight management **using Socio economic and Environmental.**	2
	PSO 2	**Focus on broad knowledge** of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	2
CO 4	PO 1	Apply the knowledge of different Navigational aids (**scientific Principles and mathematical principles**) for Flight management system (FMS) and describe different performance parameters.	3
	PO 2	Analyze the performance parameters of Automatic direction finding,distance measuring equipment using **first principles of Mathematics and engineering sciences.**	2
CO 5	PO 1	Understand the advantages of airborne early warning, ground surveillance system **using the fundamentals of engineering and mathematical equations**	3
	PO 2	Analyze the performance parameters of Automatic direction finding,distance measuring equipment using **first principles of Mathematics and engineering sciences.**	3
	PO 5	Use the modern tools for the advantages of airborne early warning, ground surveillance system **using modern Engineering and IT tools**	1
CO 6	PO 1	Analyze different Types of radar- pulse Doppler **using fundamentals of science &and engineering fundamentals.**	3
	PO 2	Categorize the concept of earth and horizon sensors based on its physical state and its usage in **complex engineering problems.**	2
	PO 5	Use the modern tools for the advantages of airborne early warning, ground surveillance system **using modern Engineering and IT tools**	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	2	-	-	-	-	-	3	-	-
CO 2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	1	-	2	-	-	-	-	-	-	-	2	-
CO 4	3	2	-	-	-	-	-	-	-	-	-		-	-	-
CO 5	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	1	-	-	-	-	-	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	20	-	-	-	-	66	-	-	-	-	-	100	-	-
CO 2	66	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	-	-	-	100	-	66	-	-	-	-	-	-	60	-
CO 4	100	20	-	-	100	-	-	-	-	-	-		-	-	-
CO 5	66	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	20	-	-	100	-	-	-	-	-	-		-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - $0 \leq C \leq 5\%$ – No correlation
2 - $40\ \% < C < 60\%$ –Moderate
1-5 $< C \leq 40\%$ – Low/ Slight
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	-	-	-	3	-	-	-	-	-	3	-	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	3	-	3	-	-	-	-	-	-	2	-
CO 4	3	1	-	-	-	-	-	-	-	-	-		-	-	-
CO 5	3	-	-	-	3	-	-	-	-	-	-	-	-	-	-
CO 6	3	1	-	-	3	-	-	-	-	-	-		-	-	-
TOTAL	18	4	-	-	9	-	-	-	-	-	-	-	3	2	-
AVERAGE	3	1	-	-	3	-	-	-	-	-	-	-	1	1	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Term Paper	-	Concept Video	✓	Open Ended Experiments	-
Assignments	-	Tech talk	✓	Mini Project	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

X	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII 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, 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. Moir, I. and Seabridge, A., Civil Avionics Systems, AIAA Education Series, AIAA, 2002.
2. Collinson, R.P.G., Introduction to Avionics Systems, second edition, Springer, 2003.

REFERENCE BOOKS:

1. Helfrick, A., Principles of Avionics, Avionics Communications Inc. Leesburg, 2000.
2. Henderson, M. F., Aircraft Instruments & Avionics for A &P Technicians, Jeppesen Sanderson Training Products, 1993.

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	In Outcome-Based Education (OBE), we discussed about course delivery assessment that are planned to achieve stated objectives and outcomes. We will focuses on measuring student performance i.e. outcomes at different levels. Course outcomes(CO),Program Outcomes(PO)and Program Specific Outcomes(PSO) and also mapping of CO's to PO's PSO's and their attainments are discussed.	-	-
CONTENT DELIVERY (THEORY)			
1	Course description CO and PO mapping	CO 1	———
2	Evolution of electronics; The nature of microelectronic devices	CO 1	T1 : 1.1,
3	Processors, memory devices	CO 1	T1 : 2.2
4	Introduction to avionics	CO 1	T1 : 2.3
5	Systems integration	CO 1	T1 : 2.4
6	Need - data bus systems	CO 1	T1 : 2.4
7	MIL STD 1553 bus system	CO 1	T1 : 2.5
8	ARINC 429 bus systems	CO 1	T1 : 2.6
9	ARINC 629 bus systems	CO 2	T1 : 2.7
10	Optical data bus systems	CO 2	T1 : 2.9
11	Integrated modular avionics architectures ,	CO 2	T1 : 2.10

12	Commercial off the shelf systems	CO 2	T1 : 2.11
13	Avionics packaging	CO 2	T1 : 2.10
14	Air data sensors.	CO 2	T1 : 3.2
15	magnetic sensing,	CO 2	T1 : 3.3
16	Inertial sensing, radar sensors	CO 2	T1 : 3.4
17	The electromechanical instrumented flight deck	CO 2	T1 : 3.4
18	Early flight deck instruments,	CO 3	T1 : 3.4
19	Attitude direction indicator	CO 3	T1 : 3.4
20	Horizontal situation indicator	CO 3	T1 : 3.4
21	Altimeter	CO 3	T1 : 3.4
22	Airspeed indicator	CO 3	T1 : 3.4
23	Advanced flight deck display system architectures	CO 3	T1 : 4.1
24	Display systems	CO 3	T1 : 4.2
25	Display media	CO 4	T1 : 4.3
26	Future flight deck displays	CO 4	T1 : 4.3
27	Radio frequency spectrum	CO 4	T1 : 4.3
28	Communication systems;	CO 4	T1 : 4.4
29	HF, VHF, satellite communications;	CO 4	T1 : 4.4
30	ATC transponder	CO 5	T2 : 3.3
31	Traffic collision avoidance system;	CO 5	T2 : 3.3
32	Navigational aids	CO 5	T1 : 4.5
33	Automatic direction finding,	CO 5	T1 : 4.5
34	VHF Omni range	CO 5	T1 : 4.5
35	Distance measuring equipment	CO 5	T1 : 4.5
36	TACAN, VORTAC;	CO 6	R1 : 6.1
37	Satellite navigation systems, the GPS.	CO 6	R1 : 6.2
38	Basic navigation, radio, inertial navigations	CO 6	R1 : 6.1.1
39	Satellite navigation;	CO 6	R1 : 6.1.3
40	GPS, differential GPS, wide area augmentation systems,	CO 6	R1 : 6.1.3
PROBLEM SOLVING/ CASE STUDIES			
1	Introduction to avionics, systems integration, need - data bus systems	CO 1	T1 : 2.6
2	Integrated modular avionics architectures	CO 1	T1 : 2.7
3	Commercial off the shelf systems; Avionics packaging.	CO 1	T1 : 3.2
4	The electromechanical instrumented flight deck	CO 2	T1 : 3.1
5	Advanced flight deck display system architectures	CO 2	T2 : 3.3.1
6	Air data sensors	CO 2	R1 : 6.2
7	ATC transponder, traffic collision avoidance system	CO 3	R1 : 6.2
8	Automatic direction finding, VHF Omni range	CO 3	R1 : 6.2
9	Basic navigation, radio, inertial navigations, satellite navigation	CO 4	R1 : 6.2
10	Avionic and mission system interface	CO 5	R1 : 6.2

11	Navigation aids, flight deck displays, communications, aircraft systems	CO 5	R1 : 6.2
12	Command and telemetry.	CO 5	R1 : 6.2
13	Attitude determination and control of spacecraft	CO 6	R1 : 6.2
14	Magnetometers, sun sensors,	CO 6	R1 : 6.2
15	Star trackers, earth and horizon sensors;	CO 6	R1 : 6.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Avionics Technology	CO 1	T1, T2
2	Aircraft Instrumentation - Sensors And Displays	CO 2	T1, T2
3	Communication And Navigation Aids	CO 3, CO 4	T1 R2
4	Military Aircraft Adaptation	CO 5	R2
5	Airborne Radar, Astrionics - Avionics For Spacecraft	CO 6	T1
DISCUSSION OF QUESTION BANK			
1	Avionics Technology	CO 1	T1
2	Aircraft Instrumentation - Sensors And Displays	CO 2	T1
3	Communication And Navigation Aids	CO 3, CO 4	T1, T2
4	Military Aircraft Adaptation	CO 5	R2
5	Airborne Radar, Astrionics - Avionics For Spacecraft	CO 6	R2

Signature of Course Coordinator **HOD, AE**
Mr.K Arun Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**AEROSPACE STRUCTURAL DYNAMICS**					
Course Code	AAEC35					
Program	B.Tech					
Semester	VII	AE				
Course Type	Core					
Regulation	IARE	UG-20				
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	3	1	4	-	-	
Course Coordinator	Mr. V Phaninder Reddy, Assistant Professor					

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSC03	I	Engineering Physics
B.Tech	AMEC01	II	Engineering Mechanics
B.Tech	AAEC01	III	Mechanics of Solids

II COURSE OVERVIEW:

Mechanical structures and systems are susceptible to vibrations, i.e. periodic changes in the physical state. Vibrations can both be a hindrance and a benefit to machines. The objective of this course is to learn how to treat the vibration phenomena by transforming the physical model into a mathematical model and solve it by using the appropriate mathematical operations to find the response and analyze this response and bring it back to its physical concept. This course also provides an introductory level knowledge in theoretical and experimental foundations of aeroelasticity.

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
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), and 10 marks for Alternative Assessment Tool (AAT).

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
35%	Understand
55%	Apply

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		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 below table

AAT-II	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to:

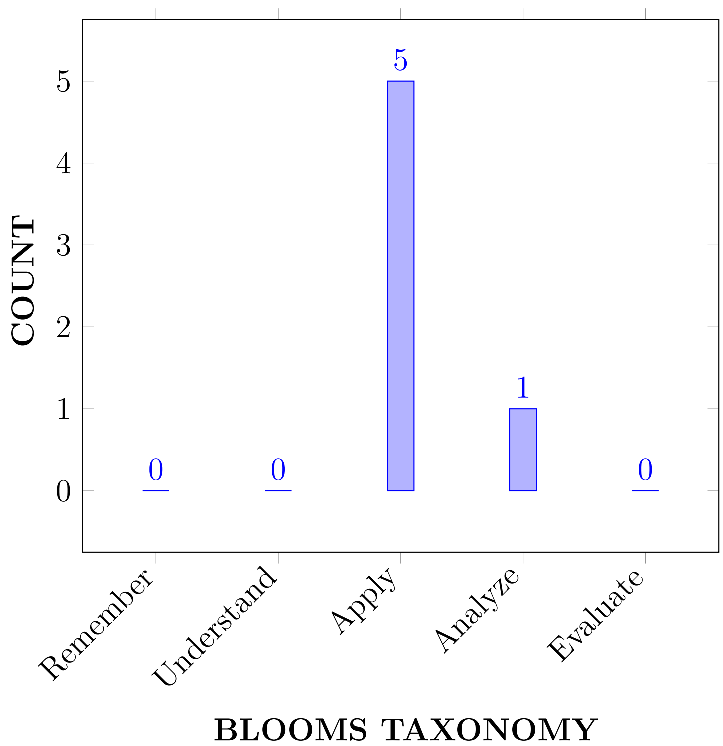
I	Formulate mathematical models of problems in vibrations using Newton's second law or energy principles.
II	Determine a complete solution to the modelled mechanical vibration problems.
III	design a mechanical system that has desirable vibrational behavior.
IV	Assess the underlying assumptions in the aeroelastic analysis of fixed wing and rotary wing aerospace vehicles/systems.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Apply** principles of mechanical vibrations such as Newton's second law, and the principle of conservation of energy to the mathematical models for obtaining their governing equations of motion.	Apply
CO 2	**Analyze** the mathematical modeling of the two degrees of freedom systems for determining the frequency of the spring-mass system.	Analyze
CO 3	**Solve** the natural frequencies and mode shapes of a multi degree of freedom system for the numerical solution of distributed parameter systems	Apply
CO 4	**Apply** theoretical and numerical procedures for predicting the dynamic response of continuous structural systems under the most diverse loading conditions.	Apply
CO 5	**Formulate** the static aeroelasticity problems such as typical section and wing divergence problems; for their selection in real world 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		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

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.	2	Quiz

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-		-	✓	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-		✓	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-		✓	-
CO 4	✓	✓	-	-	-	-	-	-	-	-	-			✓	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Understand the 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
	PO 2	Identify the formula to simplify the harmonnic response problems on free vibration by using mathematics and engineering knowledge.	2
	PSO 2	Apply the equation of free vibration system for the solving of the undamped system using engineering fundamentals.	1
CO 2	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 2	Use the equation of free and forces vibrating system for the solving of the damped and undamped system by using mathematics, science and Engineering fundamentals.	1
CO 3	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
	PO 2	Identify the formula to simplify the torsional vibrations of rotor and geared systems by **using mathematics and engineering knowledge.**	2
	PSO 2	Use the equation of multi degree of freedom vibrating system for simplifying the complex problems using engineering fundamentals.	1
CO 4	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	Identify the formula of stiffness and flexibility influence coefficients for simplifying solutions of multi DOF systems by using **mathematics and engineering knowledge**	2

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PSO 2	Apply the equation of free vibrating system for the solving of the damped and damped system using **mathematics, science and Engineering fundamentals.**	1
CO 5	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.	2
	PSO 2	Analyse the frequency of cable, shafts, beam for developing the new solutions on vibrating body using **appropriate mathematics, science and engineering fundamentals.**	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 2	2	3	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	1	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	20	-	-	-	-	-	-	-	-	-	-	-	50	-
CO 2	66.6	30	-	-	-	-	-	-	-	-	-	-	-	50	-
CO 3	100	20	-	-	-	-	-	-	-	-	-	-	-	50	-
CO 4	100	20	-	-	-	-	-	-	-	-	-	-	-	50	-
CO 5	100	20	-	-	-	-	-	-	-	-	-	-	-	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
2 - $40\% < C < 60\%$ –Moderate
1-5 $< C \leq 40\%$ – Low/ Slight
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	-	2	-
TOTAL	27	5	-	-	-		-	-	-	-	-	-	-	10	-
AVERAGE	3	1	-	-	-		-	-	-	-	-	-	-	2	-

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	**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.

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
2	Basic concepts and importance of vibration	CO 1, 2	T2: 1.1-1.5, T1: 4.1

S.No	Topics to be covered	CO's	Reference
3	Classification of vibrations with exxamples	CO 1	T2: 2.1-2.2, R1: 3.1
4	**Harmonic Analysis:** Fourier Series Expansion, Complex Fourier Series and Frequency Spectrum	CO 1	T2: 2.1-2.2, R1: 3.1
5	**Harmonic Analysis:**Time- and Frequency-Domain Representations Even and Odd Functions, Half-Range Expansions	CO 1	T2: 2.8
6	Equation of Motion Using Newton s Second Law of Motion,	CO 1	T2: 2.3-2.4
7	Response of an Undamped System Under Harmonic Force	CO 1	T2: 2.7.1
8	Transfer-Function Approach	CO 1	T2: 3.4
9	Free Vibration of an undamped torsional system	CO 1	T2: 3.4
10	Laplace transform: Transient and steady-state responses	CO 1	T2: 3.4
11	Equations of motion for forced vibration	CO 1	T2: 3.3
12	Free vibration analysis of an Undamped System	CO 2	T2:7.1
13	Torsional system, Numerical problems	CO 2	T2: 6.3.3
14	Coordinate coupling and principal coordinates	CO 2	T2: 3.2
15	Forced-vibration analysis	CO 2	T2: 3.2
16	Semidefinite systems	CO 2	T2: 3.2
17	Self-Excitation and stability Analysis	CO 2	T1 5.5
18	Transfer-function approach	CO 2	T2: 7.1
19	Solutions using Laplace transform	CO 2	T2: 5.1
20	Solutions using frequency transfer functions	CO 2	T2: 5.2
21	Using Newton's second law to derive Equations of Motion	CO 3	T2: 4.2.1
22	Influence coefficients: Stiffness influence coefficients Flexibility influence coefficients	CO 3	T2: 4.2.2
23	Equations of motion of undamped Systems in matrix form	CO 4	T1: 5.2
24	Eigenvalue problem and solution of the eigenvalue problem	CO 4	T1: 5.2
25	Free vibration of undamped systems	CO 4,5	T2: 5.2
26	Forced vibration of undamped systems using modal analysis	CO 4	T2: 5.2
27	Torsional vibrations of multi- rotor systems and geared systems	CO 4	T2: 5.2
28	Introduction to discrete time systems	CO 4	T2: 3.1-3.2
29	Transverse vibration of a string or cable: Equation of Motion	CO 4	T2: 3.1-3.2
30	Free vibration of a uniform string and free vibration of a string with both ends fixed	CO 4	T2: 3.1
30	Equation of motion and solution for a longitudinal vibration of a bar	CO 4	T2: 13.2
31	Torsional vibration of a uniform shaft	CO 4	T2:11.1-11.2
32	Lateral vibration of beams: Equation of motion	CO 4	T2:11.2-11.4
33	Lateral vibration of beams: Effect of Axial force and Effects of rotary inertia and shear deformation	CO 6	T1:11.1, T4:14.1

S.No	Topics to be covered	CO's	Reference
34	The Rayleigh-Ritz method	CO 6	T1:11.1, T4:14.4
35	Effects of Aeroelastic Forces: Divergence, Control Surface Reversal, Flutter Buffeting, and Thermal Instabilities.	CO 6	T1:11.2-11.4, T4:14.3
36	Static Aeroelasticity – Effect of Wing Flexibility on Lift Distribution and Divergence	CO 6	T2:15.3.1
37	One dimensional aeroelastic model of airfoils	CO 6	T1:11.1, T4:14.3-14.4
38	Beam-Rod representation of large aspect ratio wing	CO 6	T2:15.4
39	Eigen value and Eigen function Approach, Galerkin Approach	CO 6	T2:15.3.1
40	Dynamic Aeroelasticity: Hamilton's Principle:	CO 6	T4:14.3-14.4
41	Single Particle, Many Particles, Continuous Body	CO 6	T4:14.3-14.4
42	Eigenvalue solution of flutter equations	CO 6	T4:14.3-14.4
43	Aeroelastic behaviour of a flexible wing	CO 6	T4:14.3-14.4
44	Effect of nonlinearities – limit cycle oscillations	CO 6	T4:14.3-14.4
PROBLEM SOLVING/ CASE STUDIES			
1	Find the period, displaccement, velocity of frequency and acceleration of SHM	CO 1	T2: 1.1-1.5, T1: 4.1
2	Represent the periodic motion by an harmonic motion	CO 1	T2: 3.4
3	Find the natural frequency of a single degree of freedom system.	CO 1	T2: 2.8
4	Detemine the natural frequency of a 2DOF of a vibratory system	CO 2	T2: 3.2
5	Find frequency and mode shapes of a torsional vibrations of a shaft	CO 2	T2: 3.2
6	Determine the equations of motion of a two degree of freedom system	CO 2	T2: 3.2
7	Find the flexibility influence coefficients	CO 4	T2:5.2
8	Determine natural frequencies of a multi degree of freedom of spring mass system	CO 4	T2:5.2
9	Find the steady-state response of the system	CO 4	T2: 5.2
10	Using modal analysis, find the free-vibration response of a two-degree-of-freedom system with equations of motion	CO 3	T2: 3.1-3.2.5
11	Derive the equations of motion, using Newton s second law of motion, for each of the 3DOF systems	CO 3	T2:11.2-11.4
12	Find the natural frequencies and the free-vibration solution of a bar fixed at one end and free at the other.	CO 3	T2: 13.2.6
13	Find the natural frequencies of the tapered cantilever beam by using the Rayleigh- Ritz method.	CO 3	T4:14.3-14.4

S.No	Topics to be covered	CO's	Reference
14	Derive the frequency equation for the transverse vibration of the cable.	CO 4	T4:14.3-14.4
15	Compute the first three natural frequencies and the corresponding mode shapes of the transverse vibrations of a uniform beam	CO 4	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Define these terms: cycle, amplitude, phase angle, linear frequency, period, and natural frequency, parameters corresponding to m, c, k, and x for a torsional system	CO 1	T2: 1.1-1.5
2	logarithmic decrement, How are the amplitude, frequency, and phase of a steady-state vibration related to those of the applied harmonic force for an undamped system?	CO 2	T4:7.3
3	flexibility and stiffness influence coefficients and the relation between. Orthogonality of normal modes?	CO 4	T2:5.1, T2: 6.3-6.4
4	Aeroelasticity: Dynamic and Static, Flutter, Hamiton Principle, Wing sweep, Divergence	CO 5	T1:7.5
5	Kaplan, Francis and Pelton turbines, Centrifugal and Reciprocating pump, Euler turbine equation, characteristic curves of turbine	CO 6	T1: 12.1
DISCUSSION OF QUESTION BANK			
1	Displacement velocity frequency, amplitude of SHM.	CO 1,2	T2: 1.1-1.5
2	Representation of step function by harmonic motion	CO 3	T2: 3.2
3	Equations of motion of a Single, double and multi DOF	CO 4,5	T2:5.1
4	Lateral and lonitudinal vibrations of a bar	CO 6	T2:11.2-11.4
5	Natural frequency using Rayleigh Ritz method	CO 6	T2:5.2-11.4

Signature of Course Coordinator **HOD,AE**
Mr. V Phaninder Reddy Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**FLIGHT VEHICLE DESIGN**				
Course Code	AAEC34				
Program	B.Tech				
Semester	VII				
Course Type	CORE				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms.Sravanthi Gudikandula , Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEC09	V	Flight Mechanics
B.Tech	AAEC08	V	Aerodynamics
B.Tech	AAEC15	V	Analysis of Aircraft Structures

II COURSE OVERVIEW:

Flight Vehicle design is designed to understand the 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.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Flight Vehicle Design	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), and 10 marks for Alternative Assessment Tool (AAT).

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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
66.6 %	Apply
33.3 %	Analyze
11.1 %	Evaluate

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
	Continuous Internal Examination – 2 (Mid-term)	10	
	AAT-1	5	
	AAT-2	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			100

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Tech-talk	Quiz
50%	50%

VI COURSE OBJECTIVES:

The students will try to learn:

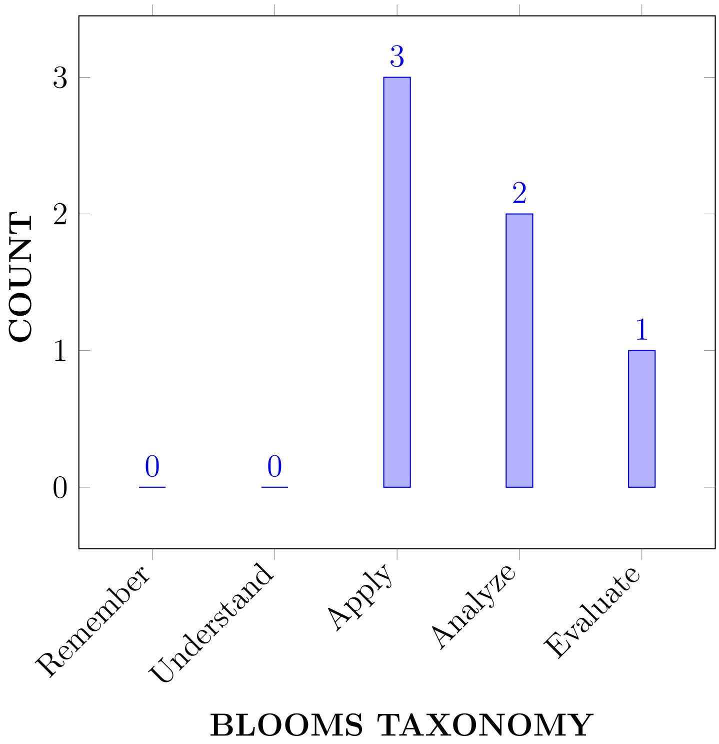
I	The fundamental concepts of various aerofoil characteristics and blend the best suitable requirements for various applications designing in various applications.
II	Initial sizing of fuselage and tail plane design; static stability; structural loading; cost analysis; takeoff and landing; and specification 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	**Choose** data collection for conceptual sketch from existingaircraft 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 calculatingthe empty weight fraction.	Evaluate
CO 6	**Identify** the total drags on an aircraft and calculate the total weight, thrustand drag for exit pressure and Mach number for the given nozzle configurations	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

Program Outcomes	
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	CIE/AAT/SEE
PO 5	Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X 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.	2	CIE/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/SEE

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 4	✓	✓	-	-	✓	-	-	-	-	-	-	-	-	-	-
CO 5	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	✓
CO 6	✓	✓	-	-	-	-	-	-	-	-	-		-	-	-

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply **the knowledge of Mathematics, Sciences and Engineering fundamentals principles** to 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.	4
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.**	4

CO 3	PO 1	Identify the role of different parts of an aircraft using **principles of mathematics, science, and engineering fundamentals.**	3
	PSO 1	Identify the role of different parts of an aircraft using **principles of mathematics, science, and engineering fundamentals.**	2
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.**	4
	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.**	3
	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
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.**	4

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE	Program Outcomes/ No. of Key Competencies Matched											PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	4	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 4	3	4	-	-	1	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 6	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	40	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	-	-	-	-	-	-	-	-	-	-	-	66.6	-	-
CO 4	100	40	-	-	100	-	-	-	-	-	-		-	-	-
CO 5	100	-	-	-	-	-	-	-	-	-	-	-	-	-	66.6
CO 6	100	40	-	-	-	-	-	-	-	-	-		-	-	-

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - $0 \leq C \leq 5\%$ – No correlation
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	2	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 4	3	2	-	-	3	-	-	-	-	-	-		-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 6	3	2	-	-	-	-	-	-	-	-	-		-	-	-
TOTAL	18	8	-	-	3		-	-	-	-	-	-	2	-	2
AVERAGE	3	2	-	-	3		-	-	-	-	-	-	2	-	2

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	Quiz	✓	Open Ended Experiments	-
Assignments	-				

XVII ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII 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.
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, relation to aircraft dynamic characteristics, 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, landing analysis, effects of wind on aircraft performance.

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

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		
CONTENT DELIVERY (THEORY)			
2	Phases of aircraft design, aircraft conceptual design process, project brief /request for proposal,	CO1	T1: 4.1
3	Problem definition, information retrieval, integrated product development and aircraft design.	CO1	T2: 2.1-2.2
4	Initial conceptual sketches, takeoff gross weight estimation	CO1	T2: 2.3-2.4
5	Airfoil selection, airfoil design, airfoil design considerations	CO1	R1: 3.3
6	Wing geometry and wing vertical location	CO1	T2: 3.3
7	Wing tip shapes, tail geometry and arrangements	CO2	R1:4.1
8	Thrust to weight ratio, thrust matching,	CO2	T2: 3.4
9	Wing loading performance, constraint analysis.	CO2	T2: 3.3
10	Sizing with fixed engine and with rubber engine.	CO2	T2: 4.2
11	Geometry sizing of fuselage, wing, tail, control surfaces,	CO2	T2: 5.1
12	Development of configuration lay out from conceptual sketch	CO2	T2: 5.2
13	The inboard profile drawing, lofting definition, significance and methods	CO3	T2: 5.3
14	Flat wrap lofting, special consideration in configuration lay out	CO3	T2: 4.5
15	In configuration lay out, Isobar tailoring, Sears-Haack volume distribution	CO3	T1: 4.1
16	The inboard profile drawing, lofting definition,	CO3	T1: 4.2
17	Significance and methods, flat wrap lofting,	CO3	R1:6.1
18	Special consideration in configuration lay out.	CO3	T2: 7.4
19	Isobar tailoring, Sears-Haack volume distribution,	CO3	T2: 8.3
20	Structural load paths,radar, IR	CO3	T2: 8.3
22	Visual detectability, aural signature,	CO3	T2: 8.3
23	Considerations of vulnerability, crashworthiness	CO4	R1:7.1
24	Producibility, maintainability, fuselage design, crew station, passengers and payload	CO4	T2: 6.4
25	Propulsion selection, jet engine integration, propeller engine integration	CO4	T2: 6.4
26	Engine design considerations, engine size estimation, fuel system design and integration, landing gear and sub systems arrangements	CO4	T2: 6.2

27	Guidelines and significance of design layout, report of initial specifications.	CO4	T2: 6.2
28	complete drag build up, installed performance of an engine, installed thrust methodology,	CO4	T2: 6.2
29	Net propulsive force, part power operation, aircraft structures and loads categories, air load distribution on lifting surfaces	CO4	T2: 6.2
30	Review of methods of structural analysis, material selection	CO4	T2: 8.1
31	Weights and moments statistical group estimation method, centre of gravity excursion control.	CO4	T2: 8.2
32	Estimation of static pitch stability, velocity stability and trim, estimation of stability and control derivatives	CO5	T2: 8.3
33	Static lateral, directional stability and trim. estimation of aircraft dynamical characteristics, handling qualities, Cooper – Harper scale	CO5	T2: 9.4, R1:4.1
34	Relation to aircraft dynamic characteristics, performance analysis and constraint analysis– steady level flight	CO5	T2: 9.4
35	Minimum thrust required for level flight, range and loiter endurance, steady climbing and descending flight	CO5	T2: 8.3
36	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	CO5	T2: 8.2
37	The aircraft operating envelope, take off analysis, balanced field length, Landing analysis, fighter performance measures of merit,	CO5	T2: 9.1
38	Effects of wind on aircraft performance, Initial technical report of baseline design analysis and evaluation,refined baseline design and report of specifications.	CO5	T2: 9.1
39	Elements of life cycle cost, cost estimating method	CO6	T2: 9.2
40	RDT and E and production costs, operation and maintenance costs, Cost measures of merit,aircraft and airline economics	CO6	T2: 9.2
41	DOC and IOC, airline revenue, breakeven analysis,Investment cost analysis, parametric analysis and optimization	CO6	T1: 7.6
42	Improved conceptual sizing methods, sizing matrix plot and carpet plot, trade studies, design trades, requirement trades, growth sensitivities, multivariable design optimization methods	CO6	T1: 7.5, R2:7.4
43	Measures of merit, determination of final baseline design configuration, preparation of type specification report	CO6	T1: 7.5, R2:7.4
44	Case studies on design of DC-3 and Boeing B-707 and 747; General dynamics F-16, SR-71 Blackbird	CO6	T1: 8.7

45	Northrop-Grumman B-2 Stealth Bomber.	CO6	R2:9.5
PROBLEM SOLVING/ CASE STUDIES			
1	Aircraft conceptual design process	CO 1	T1 : 2.6
2	Development of configuration lay out from conceptual sketch	CO 1	T1 : 2.7
3	Propulsion, Fuel System Integration Wing and tail and control surfaces.	CO 2	T1 : 3.2,3.3
4	Engine size estimation,Landing Gear and sub systems arrangements .	CO 3, CO	T1 : 3.2,3.3
5	Baseline Design Analysis and effects of wind on aircraft performance.	CO 3	T2 : 3.3.1
6	Estimation of static pitch stability, velocity stability and trim, estimation of stability.	CO 3	R1 : 6.1
7	Handling qualities, relation to aircraft dynamic characteristics, steady level flight.	CO 4	R1 : 6.2
8	Case studies on design of DC 3 and Boeing B707 and 747.	CO 5	R1 : 6.3
10	Integrated product development and aircraft design.	CO 2	R1 : 6.4
11	Flat wrap lofting, special consideration in configuration lay out.	CO 4	R1 : 6.4
12	Installed performance of an engine, aircraft structures .	CO 4	R1 : 6.4
13	Steady climbing and descending flight, best angle and rate of climb.	CO 5	R1 : 6.3
14	DOC and IOC, airline revenue, breakeven analysis.	CO 6	R1 : 6.5
15	Improved conceptual sizing methods.	CO 6	R1 : 6.6
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Overview of The Design Proces.s	CO 1	T1
2	Initial Sizing and Configuration Layout.	CO 2	R1, R2
3	Estimation of lift curve slope, maximum lift coefficient,Aircraft structures and loads categories.	CO 3, CO 4	T1, R2
4	Minimum thrust required for level flight, range and loiter endurance.	CO 5	T1
5	Multivariable design optimization methods, determination of final baseline design configuration.	CO 6	T1, T2,R1, R2
DISCUSSION OF QUESTION BANK			
1	Wing vertical location, wing tip shapes, tail geometry and arrangements.	CO 1	T1
2	Structural load paths, radar, IR, fuselage design, crew station, passengers and payload.	CO 2	T2,R1, R2
3	Guidelines and significance of design layout, report of initial specifications.	CO 3, CO 4	T1, T2,R1, R2
4	Level turning flight, gliding flight, energy maneuverability methods of optimal climb trajectories and turns.	CO 5	T1

5	Parametric Analysis, Optimization, Refined Sizing and Trade Studies.	CO 6	T1, T2,R1, R2

Signature of Course Coordinator **HOD, AE**
Ms. Sravanthi Gudikandula, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

<table>
<tr><td>Department</td><td colspan="5">AERONAUTICAL ENGINEERING</td></tr>
<tr><td>Course Title</td><td colspan="5">UNMANNED AIR VEHICLES</td></tr>
<tr><td>Course Code</td><td colspan="5">AAEC42</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td colspan="5">VII</td></tr>
<tr><td>Course Type</td><td colspan="5">Elective</td></tr>
<tr><td>Regulation</td><td colspan="5">UG-20</td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>3</td><td>-</td><td>3</td><td>-</td><td>-</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Mrs. D Karuna Kumari , Assistant Professor</td></tr>
</table>

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEC09	IV	Flight Mechanics
B.Tech	AAEC08	IV	Aerodynamics

II COURSE OVERVIEW:

The course focuses on fundamentals related to powered, aerial vehicle systems that does not carry a human operator, including the terminology related to unmanned air vehicles (UAV), subsystems, basic design phases, aerodynamics, and also provides insight into different types of airframes and power-plants. It imparts knowledge about navigation, communications, control, and stability of UAVs.The course is aimed to obtain the knowledge also in commercial, private, public, and educational interest in UAS applications.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Unmanned Air Vehicles	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), and 10 marks for Alternative Assessment Tool (AAT).

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
33.33%	Remember
50%	Understand
16.67%	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

Tech-talk	Quiz
50%	50%

VI COURSE OBJECTIVES:

The students will try to learn:

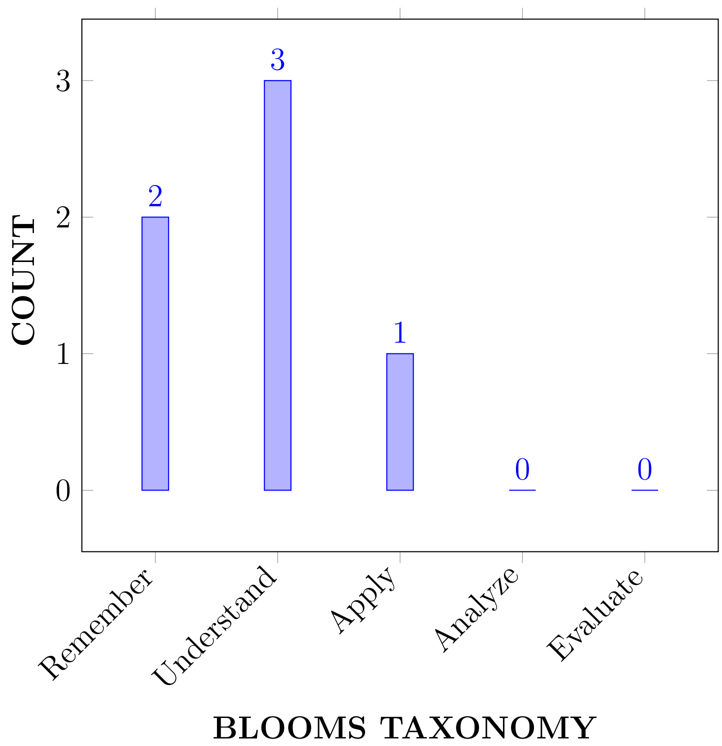
I	The major subsystems and the fundamental design phases of Unmanned Air Vehicle Systems (UAS).
II	The basic drags and airframe configurations of Unmanned Air Vehicles (UAVs).
III	The various communication media and navigation systems of UAVs.
IV	The different techniques used to achieve the control and stability of UAVs.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Demonstrate** the knowledge of basic design phases for the development of unmanned air vehicle systems.	Understand
CO 2	**Utilize** theknowledge of performance characteristics of UAV systems to select the suitable airframe design as per the mission requirement.	Apply
CO 3	**Illustrate** the different types of airframe configurations available for unmanned air vehicle systems.	Understand
CO 4	**Outline** the scaling effects, package density, basic aerodynamics, and structures concepts used during the design of UAVs.	Understand
CO 5	**Select** a suitable power-plant based on power generation systems for the given mission requirement.	Apply
CO 6	**Analyze** the attributes, performance, design issues, and compromises of different types of aircraft for UAV systems to select suitable 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.
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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.
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PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
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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	CIE/AAT/SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X 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.	2	CIE/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/SEE

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 4	✓	✓	-	-	✓	-	-	-	-	-	-	-	-	-	-
CO 5	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	✓
CO 6	✓	✓	-	-	-	-	-	-	-	-	-		-	-	-

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply **the knowledge of Mathematics, Sciences and Engineering fundamentals principles** to 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.	4
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.**	4
CO 3	PO 1	Identify the role of different parts of an aircraft using **principles of mathematics, science, and engineering fundamentals.**	3
	PSO 1	Identify the role of different parts of an aircraft using **principles of mathematics, science, and engineering fundamentals.**	2
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.**	4
	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.**	3
	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
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.**	4

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	Program Outcomes/ No. of Key Competencies Matched												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	4	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 4	3	4	-	-	1	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 6	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	40	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	-	-	-	-	-	-	-	-	-	-	-	66.6	-	-
CO 4	100	40	-	-	100	-	-	-	-	-	-		-	-	-
CO 5	100	-	-	-	-	-	-	-	-	-	-	-	-	-	66.6
CO 6	100	40	-	-	-	-	-	-	-	-	-		-	-	-

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - $0 \leq$ C$\leq$ 5% – No correlation
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	2	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 4	3	2	-	-	3	-	-	-	-	-	-		-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 6	3	2	-	-	-	-	-	-	-	-	-		-	-	-
TOTAL	18	8	-	-	3		-	-	-	-	-	-	2	-	2
AVERAGE	3	2	-	-	3		-	-	-	-	-	-	2	-	2

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	Quiz	✓	Open Ended Experiments	-
Assignments	-				

XVII ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO UNMANNED AIRCRAFT SYSTEMS**
	The systemic basis of UAS-system composition; Conceptual phase; Preliminary design; Selection of the system; Some applications of UAS.
MODULE II	**AERODYNAMICS AND AIRFRAME CONFIGURATIONS**
	Lift-induced Drag; Parasitic Drag; Rotary-wing aerodynamics; Response to air turbulence; Airframe configurations scale effects; Packaging density; Aerodynamics; Structures and mechanisms; Selection of power-plants; Modular construction; Ancillary equipment.
MODULE III	**CHARACTERISTICS OF AIRCRAFT TYPES**
	Long-endurance, long-range role aircraft; Medium-range, tactical aircraft; Close-range / battlefieldaircraft; MUAV types; MAV and NAV types; UCAV; Novel hybrid aircraft configurations; Research UAV.
MODULE IV	**COMMUNICATIONS NAVIGATION**
	Communication media; Radio communication; Mid-air collision (MAC) avoidance; communications data rate and bandwidth usage; Antenna Types NAVSTAR Global Positioning System (GPS) - TACAN -LORAN C - Inertial Navigation - Radio Tracking - Way-point Navigation.
MODULE V	**CONTROL AND STABILITY**
	HTOL Aircraft - Helicopters - OTE/OTE/SPH - Convertible Rotor Aircraft - Payload Control -Sensors – culmon filter- Autonomy.

TEXTBOOKS

1. Reg Austin, Unmanned Aircraft Systems, John Wiley and Sons., 2010.

REFERENCE BOOKS:

1. Milman and Halkias, Integrated Electronics, McGraw Hill, 1999.
2. Malvino and Leach, Digital Principles and Applications, McGraw Hill, 1986.
3. Collinson R.P.G , Introduction to Avionics, Chapman and Hall, India, 1996.
4. Bernad Etikin, Dynamic of flight stability and control, John Wiley, 1972.

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
2	Aircraft Structural components and loads	CO 1	T1:12.1
3	The systemic basis of UAS-system composition	CO 1	T2:1.1-12 T1:2.1-3
4	Conceptual phase	CO 1	T2:1.3-1.5 T1:2.3-4
5	Preliminary design	CO 1	T1: 2.12-2.13,21,22
6	Selection of the system -	CO 1	T2:.3.1-3.2
7	Some applications of UAS	CO 1	T1:3.1-4 R2:3.3
8	TSome applications of UAS	CO 1	T1:3.5-7 R2:3.4
9	Lift-induced Drag	CO 2	T2:3.4 R1: 3.1
10	Parasitic Drag	CO 2	T1-6.1 to 6.3
11	Rotary-wing aerodynamics	CO 2	T1: 8.1-8.4
12	Response to air turbulence;	CO 2	T1: 8.5-7.9
13	Airframe configurations scale effects	CO 2	T1: 7.19-7.22
14	Packaging density	CO 2	T1: 14.1-14.4
15	Aerodynamics	CO 2	T1: 14.5-14.6
16	Structures and mechanisms	CO 2	T1: 14.7
17	Selection of power-plants	CO 3	T1: 9.1-9.10
18	Modular construction; Ancillary equipment.	CO 3	T1: 10.1-10.6
19	Modular construction; Ancillary equipment.	CO 3	R3: 7.1-7.3
20	Long-endurance	CO 3	T1: 5.15
21	Long-range role aircraft	CO 4	R2-7.3.1 to 7.3.2

S.No	Topics to be covered	CO's	Reference
22	Medium-range	CO 4	T1: 21.1-21.2
23	tactical aircraft	CO 4	T1: 21.5b
24	Close-range / battlefieldaircraft	CO 4	R2:11.1-11.3
25	MUAV types	CO 5	R2:11.4-11.5
26	MAV and NAV types	CO 5	R4:1.1
27	UCAV	CO 5	R1:2.7
28	Novel hybrid aircraft configurations	CO 5	R1:2.2
29	Research UAV	CO 5	R1:3.1
30	Communication media	CO 5	R1:3.5
31	Radio communication	CO 5	R1:3.6
32	Mid-air collision (MAC) avoidance	CO 5	R1:3.6.1
33	communications data rate	CO 6	R1:3.6.2
34	bandwidth usage	CO 6	R4:3.6.3
35	Antenna Types NAVSTAR Global Positioning System (GPS)	CO 6	R1:3.14
36	TACAN -LORAN C - Inertial Navigation	CO 5	T1-13.14
37	Radio Tracking	CO 6	T1-13.16 to 13.18
38	Way-point Navigation	CO 6	T1-13.19
39	HTOL Aircraft	CO 6	T1-13.19
40	Helicopters	CO 6	T1-13.20
41	OTE/OTE/SPH	CO 6	T1-13.20
PROBLEM SOLVING/ CASE STUDIES			
42	Response to air turbulence; Airframe configurations;	CO1	T1:3.4,3.5
43	Scale effects, Packaging density; Aerodynamics;	CO 1	T1:6.1, 6.2 , 6.3
44	Communication media; Radio communication;	CO 2	T1:9.1
45	Mid-air collision (MAC) avoidance; communications data rate and bandwidth usage;	CO 2	T1:9.3, 5.2.2
46	Antenna Types;	CO 2	T2: 9.5
47	NAVSTAR Global Positioning System (GPS) ;	CO 3	T1:9.5,11.1 R3: 6.5, 10
48	TACAN -LORAN C - Inertial Navigation;	CO 3	T1:11.2, 11.3, 11.4 R3: 6.2,10
49	Radio Tracking - Way-point Navigation;	CO 4	T1:11.5, 11.6
50	HTOL Aircraft;	CO 4	T1:10.1 R4:3.5,3.6, 3.9

S.No	Topics to be covered	CO's	Reference
51	Helicopters;	CO 4	T1:10.2
52	Convertible Rotor Aircraft;	CO 5	T1:10.3
53	OTE/OTE/SPH, Payload Control -Sensors;	CO 5	T1:10.4
54	Culmon (Kalman) filter- Autonomy;	CO 6	T1:11.1, 10.6 R4: 12.2,12.3, 12.4
55	MUAV types; MAV and NAV types; UCAV;	CO 6	T1:4.4, 4.5, 4.6
56	Novel hybrid aircraft configurations; Research UAV;	CO 6	T1:4.7, 4.8
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Introduction to Unmanned Aircraft Syatems	CO 1	T1: 2.2-2.8
58	Aerodynamics and Airframe Configurations	CO 2	T1: 2.9-2.10
59	Characteristics of Aircraft Types	CO 3, CO 4	T1: 2.12-2.13,21,22
60	Communications Navigation	CO 5	T1: 14.5-14.6
61	Control and Stability	CO 6	R4:3.6
DISCUSSION OF QUESTION BANK			
62	Introduction to Unmanned Aircraft Syatems	CO 1	T1: 2.2-2.8
63	Aerodynamics and Airframe Configurations	CO 2	T1: 14.5-14.6
64	Characteristics of Aircraft Types	CO 3, CO 4	T1: 6.6
65	Communications Navigation	CO 5	T1: 2.1
66	Control and Stability	CO 6	R2:3.6.2

Course Coordinator **HOD,AE**
Mrs. D. Karuna Kumari

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	**TECHNIQUES IN WIND TUNNEL TESTING**				
Course Code	AAEC36				
Program	B.Tech				
Semester	VII				
Course Type	Elective				
Regulation	IARE - UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. Bodavula Aslesha, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEC08	IV	Aerodynamics
B.Tech	AAEC12	IV	Aerodynamics and Propulsion Laboratory
B.Tech	AAEC06	V	High Speed Aerodynamics

II COURSE OVERVIEW:

Techniques In Wind Tunnel Testing deals with development of tools employed in low speed aerodynamics and high speed aerodynamics for measuring parameters such as Pressure, Velocity and Temperature Measurements. It is multi-disciplinary subject and useful in environmental engineering, civil engineering, Automobile engineering in designing vehicle and construction and building and bridges by using low speed wind tunnel balance. 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. 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. This subject will help the students to develop the tool by using multidisciplinary techniques.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Techniques in Wind Tunnel Testing	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	x	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), and 10 marks for Alternative Assessment Tool (AAT).

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
45%	Understand
45%	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 below table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

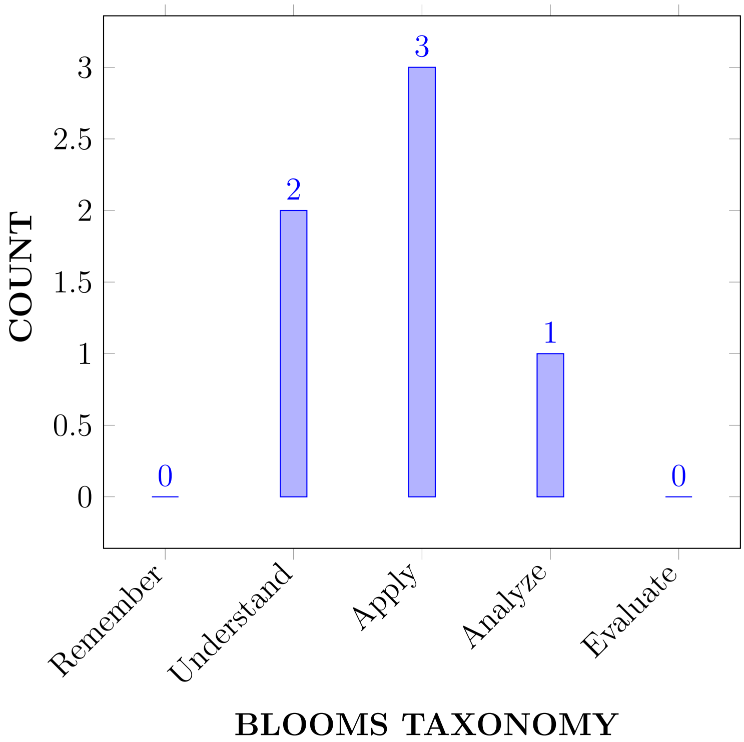
I	The constructions of low speed tunnel, high speed tunnels, transonic, supersonic and hypersonic tunnels and geometric similarity, kinematic similarity and dynamic similarity experiment techniques used for analysis aerodynamic problems.
II	The description, design constraints and loss coefficients, and 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	**Illustrate** the types of wind tunnels, Scaling Laws, Similarity parameters used for the analysis of the prototype models	Understand
CO 2	**Explain** the components and the percentage energy loss in the various parts of low and high-speed wind tunnels for obtaining the accurate results from the wind tunnel experiments	Understand
CO 3	**Select** the methods for the improvements of wind tunnel performance and corrective measures for obtaining accurate results	Apply
CO 4	**Identify** the various load balances used in the wind tunnels for analyzing the aerodynamic characteristics of designed prototype model.	Apply
CO 5	**Select** the flow measurement devices for pressure, velocity, and temperature for a prototype model.	Apply
CO 6	**Examine** the various flow visualization techniques used in wind tunnels.for the analysis of aerodynamic and automobile engineering problems.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

Program Outcomes	
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	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	2.5	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	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.	3	CIE & SEE

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 2	✓	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 4	✓	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	-
CO 5	✓	-	✓	-	-	-	-	-	-	-	-	-	✓	-	-
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 (knowledge) the need of wind tunnels and their measuring techniques (understanding) for analysis of model using geometric similarity, kinematic similarity and dynamic similarityby applying the principles of **mathematics, science and Engineering**	3
	PO 2	Understand the (**given problem statement, experimental design and problem formulate**) for analysis of model using geometric similarity, kinematic similarity and dynamic similarity (**provided information and data**) in reaching substantiated conclusions by the (**interpretation of results, and validation**)	4
	PSO 1	Apply (knowledge) the types of wind tunnels based on wind speeds (understanding) induced in body, under different loading conditions in (apply) for designing the prototypes and their applications aerospace industries by applying the principles of **mathematics, science and Engineering**	3
CO 2	PO 1	Identify(understanding) the principal components of low speed wind tunnel and their functions (apply) for determining loss coefficients and constraints (complex) by applying the **principles of mathematics, science, and engineering fundamentals.**	3
	PO 2	Identify (the given **problem statement and formulate**) the principal components of low speed wind tunnel and their functions (complex) for determining loss coefficients and constraints. (from the provided **information and data** in reaching substantiated conclusions by the **interpretation of results and validation**)	4

	PO 3	Identify (the given **problem statement and formulate**) the principal components of low speed wind tunnel balances and their functions for determining aerodynamic characteristics of a prototype model (from the provided **information and data** in reaching substantiated conclusions by the **interpretation of results and validation**)	4
	PSO 1	Identify (the given **problem statement and formulate**) the principal components of low speed wind tunnel and their functions (complex) for determining loss coefficients and constraints. (from the provided information and data in reaching substantiated conclusions by the **interpretation of results**)	3
CO 3	PO 1	Illustrate (understanding) the methods for the improvements of wind tunnel performance and corrective measures (apply) for obtaining accurate results with wind tunnel experiments (complex) by applying the **principles of mathematics, science and engineering fundamentals**	3
	PO 2	Understand (the given **problem statement and formulate**) the principals of three dimensional flows in a wind tunnel for determining boundary corrections (from the provided **information and data** in reaching conclusions by the **interpretation of results and validation**)	4
	PSO1	Apply (knowledge) for the improvements of wind tunnel performance and corrective measures (complex) for obtaining accurate results with wind tunnel experiments by applying the principles of **mathematics, science and Engineering**	3
CO 4	PO 1	Demonstrate (the knowledge) low speed wind tunnel balances, mechanical and Strain gauge types, null displacement methods and strain method and 3, 6 component balances for load measurement (complex) using wind tunnel balance by applying the principles of **mathematics, science and Engineering**	3
	PO 2	Identify (the given **problem statement and formulate**) the principal components of low speed wind tunnel balances and their functions for determining aerodynamic characteristics of a prototype model (from the provided **information and data** in reaching substantiated conclusions by the **interpretation of results**)	4
	PO 3	Experiment (the given **problem statement**) and measure the the actual forces and moments acting on model by **experimentation** (from the provided **information and data** in reaching substantiated conclusions by the **interpretation of results and validation**)	6

	PSO 1	Apply (knowledge) the model supports used in wind tunnel (apply) solving for load measurement problems by applying the principles of **mathematics, science and Engineering**	3
CO 5	PO 1	Identify the principles of probes and transducers used in (apply) in pressure, velocity and temperature measurements (complex) techniques by applying the principles of **mathematics, science and engineering fundamentals**.	3
	PO 3	Make use of (the given **problem statement and formulate**) the components of flow measurement devices for determining flow characteristics of a prototype model (from the provided **information and data** in reaching substantiated conclusions by the **interpretation of results and validation**)for pressure, velocity, and temperature measurements.	4
	PSO 1	Identify the principles of probes and transducers used in (apply) in pressure, velocity and temperature measurements (complex) techniques by applying the principles of **mathematics, science and engineering fundamentals.**	3
CO 6	PO 1	Identify (knowledge) the applications of wind tunnels for the analysis of load, pressure, velocity and temperature measurements (understanding) for the analysis of aerodynamic problems in automobile and aerospace industries. (apply) using flow visualization applying the principles of **mathematics, science and engineering fundamentals.**	3
	PO 3	Analyze (the given **problem statement and formulate**) the flow visualization technique in order to get qualitative or quantitative data (from the provided **information and data** in reaching substantiated conclusions by the **interpretation of results and validation**)	6
	PSO 1	Fabricate the model (knowledge) and focused at complex aeronautical engineering problems (understanding) for testing by using wind tunnel (apply) towards research in the area of experimental aerodynamics by applying the **principles of mathematics, science and engineering**	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	4	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 2	3	4	4	-	-	-	-	-	-	-	-	-	3	-	-
CO 3	3	4	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 4	3	4	6	-		-	-	-	-	-	-	-	3	-	-

CO 5	3	-	4	-	-	-	-	-	-	-	-	-	3	-	-
CO 6	3	-	6	-	-	-	-	-	-	-	-	-	3	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	40	-	-	-	-	-	-	-	-	-	-	100	-	-
CO 2	100	40	40	-	-	-	-	-	-	-	-	-	100	-	-
CO 3	100	40	-	-	-	-	-	-	-	-	-	-	100	-	-
CO 4	100	40	60	-		-	-	-	-	-	-	-	100	-	-
CO 5	100	-	40	-	-	-	-	-	-	-	-	-	100	-	-
CO 6	100	-	60	-		-	-	-	-	-	-	-	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 $<C<$ 40% – Low/ Slight
2 - 40 % $<C <$ 60% –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 2	3	2	2	-	-	-	-	-	-	-	-	-	3	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 4	3	2	3	-	-	-	-	-	-	-	-	-	3	-	-
CO 5	3	-	2	-	-	-	-	-	-	-	-	-	3	-	-
CO 6	3	-	3	-	-	-	-	-	-	-	-	-	3	-	-
Total	18	8	10	-	-	-	-	-	-	-	-	-	18	-	-
AVERAGE	3	2	2.5	-	-	-	-	-	-	-	-	-	3	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	-				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

X	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**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 and 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 and Strain gauge types, null displacement methods and 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 AND 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 holes 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. Jewel B Barlow, William H Rae Jr. and Alan Pope, "Low Speed Wind Tunnel Testing", John Wiley and Sons Inc, Re-Print, 1999.
2. Alan Pope, Kennith L Goin, "High Speed Wind Tunnel Testing", John Wiley and Sons, 1965.

REFERENCE BOOKS:

1. Gorlin S M and Slezinger II, Wind tunnels and Their Instrumentations, NASA publications, Translated version, 1966 .
2. Jorge C Lerner and Ulfilas Boldes, Wind Tunnels and Experimental Fluid Dynamics research, InTech, 1st Edition, 2011.

COURSE WEB PAGE:

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
2	Introduction and need of experimental test	CO 1	T1:1.1
3	Forms of aerodynamic experiments, observations, measurement objectives	CO 1	T1: 1.1
4	History: Wright Brothers wind tunnel, model testing, Wind tunnel principles	CO 1	T1:12.3
5	Scaling laws, scale parameters, Geometric similarity, kinematic similarity dynamic similarity	CO 1	T1:14.2 R2:4.25
6	Transonic, supersonic and Hyper-sonic tunnels	CO 1	T1:5.6 T2:15.2
7	Shock tubes, Special Wind tunnels	CO 1	T1:5.6 T2:15.2
8	Wind tunnels for industrial and various applications apart from aerospace requirements	CO 1	T1:5.6 T2:15.2
9	Low speed wind tunnels, principal components	CO 1	T1:5.6 T2:15.2
10	Function, description, design requirements	CO 2	T2:5.6 R1:22.5
11	constraints and loss coefficients	CO 2	T2:5.6 R1:22.5
12	Wind tunnel performance flow quality, power losses	CO 2	T1:9.1 R1:22.6
13	Wind tunnel corrections, Sources of inaccuracies: buoyancy	CO 3	T1:9.1 R1:22.6
14	Solid blockage, wake blockages	CO 3	T2:18.20 T2:11.1
15	Streamline curvature causes, estimation and correction	CO 3	T2:18.20 T2:11.1

S.No	Topics to be covered	CO's	Reference
16	Load measurement: low speed wind tunnel balances, mechanical	CO 3	T2:18.20 T2:11.1
17	Strain gauge types, null displacement methods and strain method	CO 3	T2:18.20 T2:11.1
18	SSensitivity, weigh beams, steel yard type and current balance type	CO 3	T2:18.20 T2:11.1
19	Model support three-point wire support, three-point strut support	CO 3	T2:18.20 T2:11.1
20	Platform balance, yoke balance	CO 4	T1:16.1
21	Strain gauge, 3-component strain gauge balance	CO 4	T1:16.1
22	3-component strain gauge balance, Description, Application	CO 4	T1:16.6
23	Pressure: static pressure, surface pressure orifice, static probes	CO 4	T1:16.6
24	Pitot probe for total pressure, static pressure and flow angularity	CO 4	T1:17.1
25	Pressure sensitive paints, steady and unsteady pressure measurement	CO 4	T1:17.1
26	Various types of pressure probes and transducers, errors in pressure measurement	CO 4	T2:6.4 R2:6.2
27	Temperature: measurement of temperature using thermo couples, resistance thermometers	CO 4	T1:18.1.2
28	Temperature sensitive paints and liquid crystals. Velocity: measurement of airspeed	CO 5	T1:20.1
29	Basic terminology-laminae, laminates, Manufacture – Initial form of constituent Materials, Layup, Curing, Strength	CO 5	T1:20.2
30	Mach number from pressure measurements, flow direction, boundary layer profile using pitot static probe	CO 5	T1:16.3
31	5 hole probe yaw meter, total head rake, Hot wire anemometry	CO 5	T2:22.5
32	Laser Doppler anemometry and working principle	CO 5	T2:22.5
33	observation, recording, interpretation of imagery	CO 5	T2:22.5
34	Flow visualization: necessity, streamlines, streak lines, path lines, time lines	CO 6	T1:27.1
35	Tufts, china clay, oil film	CO 6	T1:27.1
36	Smoke, hydrogen bubble	CO 6	T1:27.1
37	Optical methods: density and refractive index, schlieren system	CO 6	T1:23.8 T2:19.14
38	Convex lenses, concave mirrors, shadow graph, interferometry	CO 6	T1:22.4, T2:5.18
39	Interferometry, working principle, description, setting up, operation	CO 6	T1:22.4, T2:5.18
40	Relative merits and applications.	CO 6	T1:22.4, T2:5.18

S.No	Topics to be covered	CO's	Reference
PROBLEM SOLVING/ CASE STUDIES			
1	Different Types of Low speed wind tunnel	CO 1	R2:7.5
2	Different types of high-speed wind tunnel	CO 1	R2:7.5
3	Kinematic, dynamic, geometric similarities	CO 1	R2:7.5
4	Test section blockage ratio	CO 2	R2:7.5
5	Energy Gyration	CO 2	R2:7.5
6	SLoads and forces measured in platform-type balance	CO 3	R2:7.5
7	Loads are forces measured in Yoke-type balance	CO 3	R2:7.5
8	Balance calibration	CO 4	R2:7.5
9	Pitot static tube, u tube manometer.	CO 4	R2:7.5
10	particle Image velocimetry	CO 4	R2:7.5
11	Air speed measurements	CO 5	R2:7.5
12	Flow visualization techniques used in wind tunnel	CO 5	R2:7.5
13	Components of Shadow graph system.	CO 6	R2:7.5
14	Components of schlieren system	CO 6	R2:7.5
15	Merits and demerits of flow visualization techniques	CO 6	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Module I: Fundamentals of Experiments in Aerodynamics	CO 1	R2:7.5
2	Module II: Wind Tunnel Experimentation Considerations	CO 2	R2:7.5
3	Module III:Wind Tunnel Balance	CO 3,4	R2:7.5
4	Module IV:Pressure, Velocity and Temperature Measurements	CO 5	R2:7.5
5	Module V:Flow Visualization Techniques	CO 6	R2:7.5
DISCUSSION OF QUESTION BANK			
1	Module I: Numericals on Fundamentals of Experiments in Aerodynamics.	CO 1	R2:2.1
2	Module II:Numerical problems related to Wind Tunnel Experimentation Considerations.	CO 2	T2:7.3
3	Module III: Numerical problems related to Wind Tunnel Balance.	CO 3,4	R2:5.1
4	Module IV:Numerical problems related to Pressure, Velocity and Temperature Measurements	CO 5	T1:7.5
5	Module V:Numerical problems related to Flow Visualization Techniques	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,AE**
Dr. Bodavula Aslesha, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**AEROSPACE STRUCTURAL DYNAMICS LABORATORY**				
Course Code	AAEC45				
Program	B.Tech				
Semester	VII	AE			
Course Type	CORE				
Regulation	IARE -UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Dr. Indradeep Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AAEC06	IV	Aerospace structures	4
UG	AAEC15	V	Analysis of Aircraft structures	4

II COURSE OVERVIEW:

This course focuses on mechanical devices that are designed to have mobility to perform certain functions. In this process they are subjected to some forces. This course will provide the knowledge on how to analyze the motions of mechanisms and design mechanisms to give required strength. This includes relative static and dynamic force analysis and consideration of gyroscopic effects on aero planes, ships, automobiles like two wheelers and four wheelers. Balancing of rotating and reciprocating masses, friction effect in brakes clutches and dynamometers are also studied. Mechanical vibrations give an insight into the various disturbances while designing vibratory systems.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Aircraft Structural 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 COURSE OBJECTIVES:

The students will try to learn:

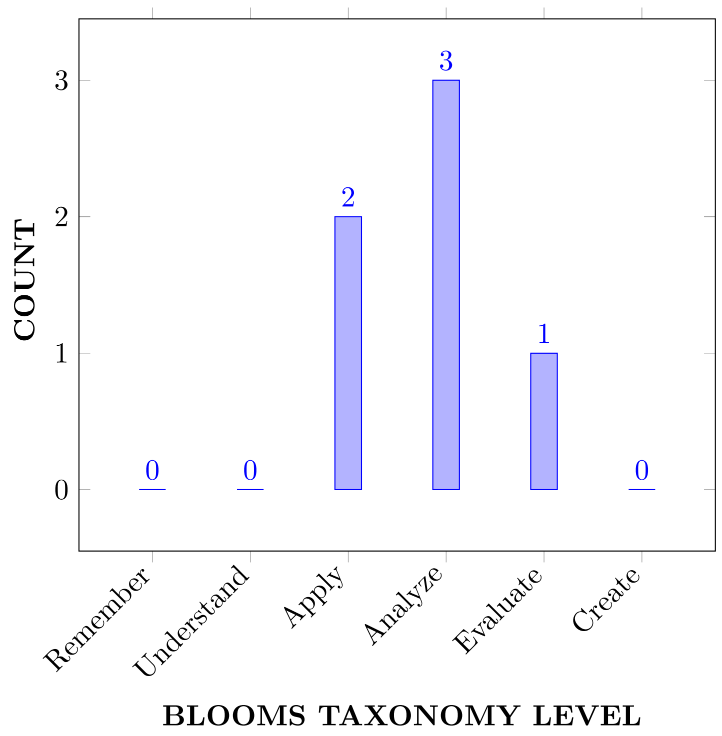
I	The Importance of theory of machines and mechanism involved in the day-to-day life, and study of basic mechanisms and inversion mechanisms to form a machine.
II	The information related design and analysis of mechanisms for a specific type of motion in a machine.
III	The developmental use of rigid bodies motions and forces for transmission system, machine kinematics.

VII 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	**Analyze** the inversion mechanism for 4-bar mechanism to form different mechanical components.	Analyze
CO5	**Determine** the shafts material for sustaining the vibrations during critical speed of the shafts	Evaluate
CO6	**Examine** the different balancing techniques for effective balancing of machines and structures.	Analyze

COURSE COURSE KNOWLEDGE COMPETENCY LEVEL:



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	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

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
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 desired higher studies.	2	Lab Exercises

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	Recall (knowledge) the basic steps involved in design and manufacturing and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and engineering fundamentals.	2
	PO 2	Understand the given **problem statement and apply data validation techniques to solve** (complex) specific engineering problems related to making of governors	3
CO 2	PO 1	Identify (knowledge) in suitable methods involved during welding for error free components using in solving (complex) engineering problems by applying the principles of **mathematics and engineering fundamentals**	2
	PO 2	Understand the given **problem statement and apply data validation techniques to solve** (complex) specific engineering problems related to welding in identification of process adoption for the specially develop component.	3
CO 3	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals.**	2
	PO 5	Create, select, and apply metal forming techniques, resources, and modern **engineering tools** including prediction and modeling to **complex engineering activities** with an understanding of the limitations.	2
CO 4	PO 1	Recall (knowledge) the basic molding processes uses plastics and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals.**	2
	PSO 3	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 5	PO 1	Identify (knowledge) in suitable methods involved in design, casting to achieve error free components using in solving (complex) engineering problems by applying the principles of **mathematics and engineering fundamentals**	2
	PO 5	Design the ball bearing and estimation of life, and **modern engineering tools** including prediction and modeling to **complex engineering activities** with an understanding of the limitations.	2

	PO 9	Design and develop the journal bearing effectively as an individual, and as a member in **diverse teams, and in multidisciplinary** settings for different lubricant effectively in building of product.	2
CO 6	PO 1	Recall (knowledge) the basic concepts of manufacturing processes and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals** for better solution.	2
	PO 5	Create, select, and apply appropriate mechanisms parameters, resources, and modern **engineering tools** including prediction and modeling to **complex engineering activities** with an understanding of the limitations for effective optimization of prototype / products.	2
	PSO 3	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2

3 = High; 2 = Medium; 1 = Low

XIII MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	**PROGRAM OUTCOMES**												**PSO'S**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	**10**	**10**	**11**	**1**	**5**	**3**	**3**	**12**	**5**	**12**	**8**	**5**	**11**	**7**
CO 1	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 5	2	-	-	-	1	-	-	-	2	-	-	-	-		-
CO 6	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
	3	**10**	**10**	**11**	**1**	**5**	**3**	**3**	**12**	**5**	**12**	**8**	**5**	**11**	**7**
CO 1	67	30	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	67	30	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	67	-	-	-	100	-	-	-	-	-	-	-	-	-	-
CO 4	67	-	-	-	-	-	-	-	-	-	-	-	-	-	29
CO 5	66	-	-	-	100	-	-	-	17	-	-	-	-	-	-
CO 6	66	-	-	-	100	-	-	-	-	-	-	-	-	-	29

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	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	3	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 5	3	-	-	-	3	-	-	-	2	-	-	-	-	-	-
CO 6	3	-	-	-	3	-	-	-	-	-	-	-	-	-	2
TOTAL	**18**	**2**	**0**	**0**	**9**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**4**
AVERAGE	**3**	**1**	**0**	**0**	**3**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**2**

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-

XVII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVIII SYLLABUS:

WEEK 1	**GOVERNOR**
	To study the function of a Governor. i) To study the effect of governor for the real applications in Piston engine, turbojet, Turboprop, and Turboshaft engine using simulation tools like SolidWorks, Fusion 3600, and ANSYS etc. ii) Undertake analytical study of the governor using mathematical tools like MATLAB, SciLab, and Excel etc. iii) Study the efficiency to compare different types of the governor used for power plant/industry purposes using free computational tools by simulating in SolidWorks, Fusion 3600.
WEEK 2	**GYROSCOPE**
	To determine the Gyroscope couple.i) To measure the precession rate of a gyroscope and compare it to the theoretical value using free apps like Gyroscope App, AndoSensor. ii) Demonstrate computationally that two disks spinning in opposite directions at the same angular speed will not precess when a torque is applied using Apps like Gyroscope Test. iii) Application and validation of Gyroscope fitted on RC plane and Drones and its operation on real field data collection with different flight attitudes using mobile Apps like Andro Sensor, Metal Sniffer, and Clinometer etc.
WEEK 3	**STATIC FORCE ANALYSIS**
	To draw free body diagram and determine forces under static condition.i) To study the static forces by free body diagram using experimental setup and also CAD tools and analysis by ANSYS/ NASTRAN/PATRAN. ii) To apply the Equations of motion to find forces and moments in static conditions by using accelerometer and Mathematical tools like MatLAB, Maple, SCILab etc. iii) To analyze the results using statistical tools like Python, Excel, SPSS, Stata, MatLab etc.
WEEK 4	**DYNAMIC FORCE ANALYSIS**
	To draw free body diagram and determine forces under dynamic condition.i) To study the dynamic forces by free body diagram using CAD tools and analysis by ANSYS/ NASTRAN/PATRAN ii) To apply the Equations of motion to find forces and moments in dynamic conditions by using Mathematical tools like MatLAB, Maple, SCILab etc. iii) To analyze the results using statistical tools like Python, Excel, SPSS, Stata, MatLab etc.

WEEK 5	**BALANCING**
	To determine balancing forces and reciprocating masses. i) To determine balancing of automobile wheel and its impact. Taking students to wheel balancing shop and to demonstrate its working principles. Mobile apps line Wheel Alignment, Smart Balance Wheel, CEMB App etc. ii) To balance of the piston engines by using computational tools / sensors and its programming by using software like ProSim Plus. iii) Use BILCO: Free software for data reconciliation for mass balancing of shaft, piston engine, turbo engines etc.
WEEK 6	**BEARING**
	To determine the bearing life.i) Bearing analysis of different loads acting on it by using Engineering software like MESys, SABR Bearing analysis software etc. ii) Advance simulation of rolling bearing as part of full electromagnetic system using bearing analysis software. iii) Use of shaft design software to find bearing life and load variations using SHAFT, ShaftDesigner, MITCALC etc.
WEEK 7	**LONGITUDINAL AND LATERAL VIBRATIONS**
	To determine the longitudinal and transfer vibration. i)Determine the longitudinal vibrations on shaft and its solution using hand held mobile App "Vibration meter app called seismograph or seismometer" using in Google Play sore can be used for strength of vibration, quakes, earthquakes, vibrations of the human body or any other objects around you. ii) Determine the lateral vibrations on shaft using computational or hand held mobile App simulating tools like WiSER Vibe Pro, Vibration Checker, and Resonance – Vibration Analyzer etc. iii) Use of coding for vibrational analysis of the automobiles, RC airplanes, Drones, Bikes, DJ sound vibrations etc. by using free software like enDAQ Cloud, GNU Octave, SciLab etc.
WEEK 8	**VIBRATION ANALYSIS OF SHAFT**
	To determine critical speed of a shaft.i) Analyze the vibrations on shaft and its solution using hand held mobile App "Vibration meter app called seismograph or seismometer" using in Google Play sore can be used for strength of vibration, quakes, earthquakes, vibrations of the human body or any other objects around you. ii) Determine the vibrations of the shaft using computational or hand held devices like WISER Vibe Pro, Vibration checker and resonance analyzer. iii) Use of coding for vibrational analysis of the automobiles, RC airplanes, Drones, Bikes, DJ sound vibrations etc. by using free software like enDAQ Cloud, GNU Octave, SciLab etc.
WEEK 9	**MECHANISMS**
	To design various mechanism and their inversions.i) Design, analyze, and optimize different mechanism Like Spring, Fixate, Links that can be found in multi-link Mechanism used in aircraft/ Automobiles using MechDesigner software,Fusion, SimScale, FlexSim etc. ii) Start a machine simulation from scratch. To create a simulation, each of these simulators provides different sets of tools Wheel, Gear, Chain, , Join, etc. iii) To design a simple mechanical simulation like gear simulation, engine piston movement simulation, basic petrol motor simulation, using free software like Phun, Algodoo, Linkage, FreeCAD, FreeDyn etc.

WEEK 10	**DIFFERENTIAL GEAR BOX**
	To study automobile differential gear box. i) Study of the differential gear box by using free open software like SolidWorks, Algodoo, Linkage, and FreeCAD etc. ii) Find the transmission error due to loss of speed by using suitable design tools like SolidWorks, Algodoo, Linkage, and FreeCAD etc. iii) Use simulating and analysis tool to find efficiency of the drive using like SolidWorks, Algodoo, Linkage, and FreeCAD etc.
WEEK 11	**FREE AND FORCED VIBRATION OF CANTILEVER BEAM**
	To study various intermittent mechanism.i) To Study the natural frequency of the cantilever beam using Analytical method and also results to be compared with Matlab/ Maple/ SciLab for free and forced vibrations of the beam. ii) Find the mass of the accelerometer at the free end of the cantilever beam using modern computational tools or Apps like AccelMeter, iSiesmo, and Librinth 2 Lite etc. iii) To determine the vibration level on a beam and assess the vibration in human parts like hand, leg by putting some specified loads by using free Apps like WiSER Vibe Pro, Vibration Checker, and Resonance – Vibration Analyzer etc.
WEEK 12	**EXAMINATIONS**
	i) This examination should be on the new concepts related to the topics given as per syllabus above. ii) Questions should be framed in such a way that application of the modern tools in real world problems to be undertaken by the students.

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.

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
1	(a)To study the functioning of a Governor. (b)To understand how the governor is balanced it weights at different speeds.	CO 1	T1:2.1.5 T2:2.3
2	(a) To determine the Gyroscope couple. (b) To study the Gyroscopic effect on rotating disc.	CO 2	T2:2.1.5 R1:2.6
3	(a)To draw free body diagram and determine forces under static condition. (b)To observe the effect of unbalanced forces in rotating mass system.	CO 2	T1:2.6 R3:3.6.5

4	(a)To draw free body diagram and determine forces under dynamic condition. (b)To observe the effect of unbalanced forces in rotating mass system.	CO 3	T2:2.7 R2:2.18
5	(a)To determine balancing forces and reciprocating masses. (b)To study how bearings will help reduce friction.	CO 3	T2:2.22 R3:3.1.1
6	(a)To study the longitudinal vibration of helical spring (b) To determine the frequency and time period of oscillation theoretically and actually by experiment	CO 4	T1:2.5.1 T2:2.25
7	(a)To determine the frequency of different shafts.. (b) The difference between the theoretical speed of whirling and actual speed can be observed.	CO 4	T2:2.26 R3:2.55
8	(a)To design various mechanism and their inversions. (b) To study a progressive tool and perform blanking and piercing operations.	CO 5	T2:2.3 R3:2.6
9	(a)To study automobile differential gear box. (b) To study different types of gear box for an automobile.	CO 5	T2:2.3 R1:2.6
10	(a)To study the forced vibration of the beam for different damping. (b) To study types of vibrations.	CO 6	T1:2.6
11	(a)To study the forced vibration of the cantilever beam for different damping. (b) To study types of vibrations of beam with natural frequency.	CO 6	T1:2.6
12	Examination	-	-

XX EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	**Design Oriented Experiments**
1	Design of Gyroscope for aircraft/ RC planes.
2	Design of engine governor for propeller Aircraft.
3	Design of ball bearing for different loads and estimation of life.
4	Design of differential gear box for Airplane landing gears.
5	Design of Fuselage and landing gears.

Prepared by: **HOD,AE**
Dr. Indradeep Kumar, Assistant. Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions	**10**

	5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**

PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project.	**12**

	6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	
PO 10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (**Communication).** "Students should demonstrate the ability to communicate effectively in writing / Orally" 1. Clarity (Writing) 2. Grammar/Punctuation (Writing) 3. References (Writing) 4. Speaking Style (Oral) 5. Subject Matter (Oral)	**5**
PO 11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PSO1	Build Embedded Software and Digital Circuit Development platform for Robotics, Embedded Systems and Signal Processing Applications 1. Analyze and solve real time problems in Robotics 2. Evaluate the design and provide optimal solutions of the digital circuits for signal processing applications 3. Develop embedded systems modules using Real Time Operating System 4. Undertake research and development projects in the field of Embedded Systems 5. Adopt the engineering professional code and conduct	**5**
PSO2	Focus on the Application Specific Integrated Circuit (ASIC) Prototype designs, Virtual Instrumentation and System on Chip (SOC) designs 1. Inspect, survey and analyze types of ASIC chip designs 2.Design ASIC prototypes using Verilog and VHDL languages 3. Analyze microprocessor subsystems with memories and I/O interfacs for SOC designs 4. Explore hardware components for designig SOC 5. Adopt the engineering professional code and conduct 6.Designing prototypes of SOC using programming tools like MATLAB, LabVIEW 7.Familiarize with the design flow of ASIC prototype 8.Realize SOC using Register-Transfer-Level designs 9. Analyse and develop models for system level descriptions for synthesis of SOC 10. Inspect and survey the abstractions and principles for the specification, simulation, verification, and synthesis of systems on chip (SoC) 11. Programming and hands-on skills to meet requirements of global environment	**11**

PSO3	Make use of High Frequency Structure Simulator (HFSS) for modeling and evaluating the Patch and Smart Antennas for Wired and Wireless Communication Applications 1. Explicit software and programming tools for antenna design 2. Adopt technical library resources and literature search 3. Explore smart antennas 4. Model, program for operation and control of smart antennas for wireless communication applications 5. Interface automation tools 6. Research, analysis, problem solving and presentation using software aids 7.Programming and hands-on skills to meet requirements of global environment	**7**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**Flight Vehicle Design Laboratory**				
Course Code	AAEC44				
Program	B.Tech				
Semester	VII				
Course Type	Laboratory				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Ms. D Anitha, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEC34	VII	Flight Vehicle Design

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
Flight Vehicle Design Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

X	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks 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. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

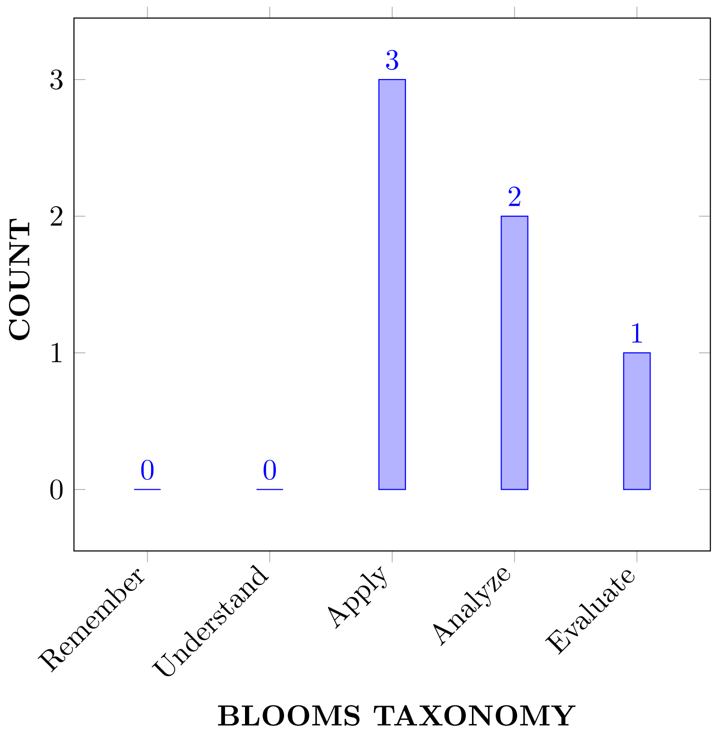
The students will try to learn:

I	Draw conceptual sketch of aircrafts based on client requirements such as type, role, payload, mission, aerodynamic & performance requirements.
II	Estimate total takeoff gross weight, thrust-weight ratio, wing loading parameters using data sheets.
III	Develop initial layouts for major components such as fuselage, empennage, landing gears and wings.

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.
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	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	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	CIE, SEE

3 = High; 2 = Medium; 1 = Low

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES			PSO'S
	PO 1	PO 3	PO 5	PSO 3
CO 1	2	-	-	2
CO 2	2	-	2	2
CO 3	2	2	-	2
CO 4	2	-	2	2
CO 5	2	2	2	2
CO 6	2	2	-	2

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-

XIII ASSESSMENT METHODOLOGY INDIRECT:

X	Early Semester Feedback	**X**	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**OBJECTIVES AND REQUIREMENTS OF THE VEHICLE**
	Data collection for conceptual sketch from existing aircraft includes : a. Type, Role, Mission b. Payload c. Aerodynamic and Performance requirements
WEEK II	**CONCEPTUAL SKETCH AND WEIGHT ESTIMATION**
	a. 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 ANALYSIS**
	Determination of Thrust-to-Weight ratio and Wing Loading
WEEK V	**INITIAL SIZING-I**
	Rubber engine & 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 b. Design study B-747
WEEK XII	**DESIGN CASE STUDY-II**
	a. Dynamics of F-16 b. Dynamics of SR-71

TEXTBOOKS

1. Daniel P. Raymer —Aircraft Design a Conceptual Approach, 5th Edition 1999.

REFERENCE BOOKS:

1. E. H Bruhn, "Analysis and Design of Flight Vehicles Structures", Jacobs Publishing House, USA, New Edition, 1973.

2. E. E Scheler, L.G Dunn, "Airplane Structural Analysis and Design", John Wiley and Sons, USA, 1963

3. D. Howe, "Aircraft conceptual Design Synthesis", John Wiley and Sons Publishers, USA, 2005.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Determine the Data collection for conceptual sketch from existing aircraft includes Mission and Payload Aerodynamic and performance requirements	CO 1	R: 1.1
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

XVI 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. D Anitha, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	AERONAUTICAL ENGINEERING				
Course Title	AVIONICS AND INSTRUMENTATION				
Course Code	AAEC50				
Program	B.Tech				
Semester	VIII				
Course Type	Elective-V				
Regulation	UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr.K Arun Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEC24	VI	Aircraft Stability and Control

II 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

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Avionics And Instrumentation	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
30%	Evaluate
0%	Understand
60 %	Apply
10 %	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

Tech-talk	Concept Video
50%	50%

VI COURSE OBJECTIVES:

The students will try to learn:

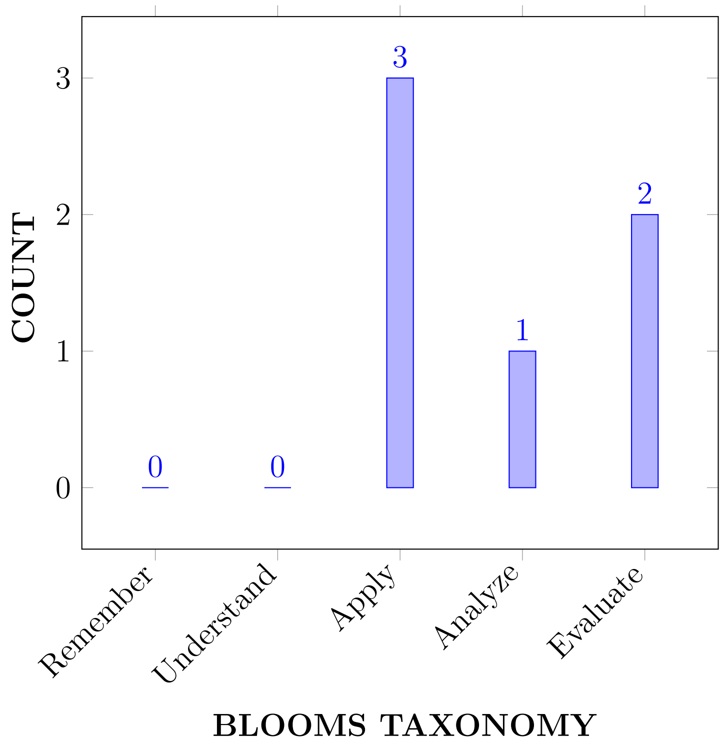
I	The principles of sensors, radars, radio communication and navigation systems and their application.
II	The Concept of microelectronic devices along with their evolution and applications, with the emphasis on digital data buses.
III	The advances in modern avionics systems, and their application in military and civil aircrafts.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Make use of** various electronic instrument and avionics systems used for the design of modem aircraft.	Apply
CO 2	**Analyze** the fundamental principles of various types of sensors for monitoring the parameters in an aircraft.	Analyze
CO 3	**Choose** the working principles of various flight instruments in flight deck for monitoring the status of the flight in one integrated display.	Evaluate
CO 4	**Develop** the basic principle and various types of navigation systems for providing accurate position of a moving aircraft relative to the earth.	Apply
CO 5	**Make use of** the concept of various navigational aids that guide the pilot for landing the aircraft safely on a runway.	Apply
CO 6	**Choose** the working principle of different sensors, radars, transmitters and magnetometers for determination of dipole moment, position and attitude.	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/SEE/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	CIE/SEE/AAT
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	CIE/SEE/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/SEE/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM 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	CIE/SEE
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	2	CIE/SEE

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	✓	-	-	-	-		✓	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	✓	-	✓	-	-	-	-	-	-	✓	-
CO 4	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	✓	✓	-	-	✓	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	-	-	✓	-	-	-	-	-	-		-	-	-

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** to classify various microelectronic devices, processors, memory devices	3
	PO 2	**Identify the problem statement** (data bus systems), select the appropriate Integrated modular avionics architectures (information and data collection) suitable to mission requirement	2
	PO 7	Analyze the performance parameters of Automatic direction finding,distance measuring equipment to **Understand the impact of the professional Engineering solutions in societal and Environmental contexts**	2
	PSO 1	**Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering** in aeronautical systems including air traffic controls standards	2
CO 2	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** and Advanced flight deck display system architectures.	3
	PO 2	Analyze the performance parameters of Automatic direction finding,distance measuring equipment using **first principles of Mathematics and engineering sciences.**	2
CO 3	PO 1	Identify various Avionic and mission system interface, navigation and flight management **using principles of mathematics, science, and engineering fundamentals.**	3

Course Outcomes	**PO'S PSO'S**	**Justification for mapping (Students will be able to)**	**No. of Key competencies matched.**
	PO 5	Identify various Avionic and mission system interface, navigation and flight management **using modern Engineering and IT tools**	1
	PO 7	Identify various Avionic and mission system interface, navigation and flight management **using Socio economic and Environmental.**	2
	PSO 2	**Focus on broad knowledge** of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	2
CO 4	PO 1	Apply the knowledge of different Navigational aids (**scientific Principles and mathematical principles**) for Flight management system (FMS) and describe different performance parameters.	3
	PO 2	Analyze the performance parameters of Automatic direction finding,distance measuring equipment using **first principles of Mathematics and engineering sciences.**	2
CO 5	PO 1	Understand the advantages of airborne early warning, ground surveillance system **using the fundamentals of engineering and mathematical equations**	3
	PO 2	Analyze the performance parameters of Automatic direction finding,distance measuring equipment using **first principles of Mathematics and engineering sciences.**	3
	PO 5	Use the modern tools for the advantages of airborne early warning, ground surveillance system **using modern Engineering and IT tools**	1
CO 6	PO 1	Analyze different Types of radar- pulse Doppler **using fundamentals of science &and engineering fundamentals.**	3
	PO 2	Categorize the concept of earth and horizon sensors based on its physical state and its usage in **complex engineering problems.**	2
	PO 5	Use the modern tools for the advantages of airborne early warning, ground surveillance system **using modern Engineering and IT tools**	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	2	-	-	-	-	-	3	-	-
CO 2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	1	-	2	-	-	-	-	-	-	-	2	-
CO 4	3	2	-	-	-	-	-	-	-	-	-		-	-	-
CO 5	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	1	-	-	-	-	-	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	20	-	-	-	-	66	-	-	-	-	-	100	-	-
CO 2	66	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	-	-	-	100	-	66	-	-	-	-	-	-	60	-
CO 4	100	20	-	-	100	-	-	-	-	-	-		-	-	-
CO 5	66	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	20	-	-	100	-	-	-	-	-	-		-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - 0$\leq$ C$\leq$ 5% – No correlation
2 - 40 % <C < 60% –Moderate
1-5 <C$\leq$ 40% – Low/ Slight
3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	-	-	-	3	-	-	-	-	-	3	-	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	3	-	3	-	-	-	-	-	-	2	-
CO 4	3	1	-	-	-	-	-	-	-	-	-		-	-	-
CO 5	3	-	-	-	3	-	-	-	-	-	-	-	-	-	-
CO 6	3	1	-	-	3	-	-	-	-	-	-		-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
TOTAL	18	4	-	-	9	-	-	-	-	-	-	-	3	2	-
AVERAGE	3	1	-	-	3	-	-	-	-	-	-	-	1	1	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Term Paper	-	Concept Video	✓	Open Ended Experiments	-
Assignments	-	Tech talk	✓	Mini Project	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

X	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII 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, 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. Moir, I. and Seabridge, A., Civil Avionics Systems, AIAA Education Series, AIAA, 2002.
2. Collinson, R.P.G., Introduction to Avionics Systems, second edition, Springer, 2003.

REFERENCE BOOKS:

1. Helfrick, A., Principles of Avionics, Avionics Communications Inc. Leesburg, 2000.
2. Henderson, M. F., Aircraft Instruments & Avionics for A &P Technicians, Jeppesen Sanderson Training Products, 1993.

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	In Outcome-Based Education (OBE), we discussed about course delivery assessment that are planned to achieve stated objectives and outcomes. We will focuses on measuring student performance i.e. outcomes at different levels. Course outcomes(CO),Program Outcomes(PO)and Program Specific Outcomes(PSO) and also mapping of CO's to PO's PSO's and their attainments are discussed.	-	-
CONTENT DELIVERY (THEORY)			
1	Course description CO and PO mapping	CO 1	———
2	Evolution of electronics; The nature of microelectronic devices	CO 1	T1 : 1.1,
3	Processors, memory devices	CO 1	T1 : 2.2
4	Introduction to avionics	CO 1	T1 : 2.3
5	Systems integration	CO 1	T1 : 2.4

6	Need - data bus systems	CO 1	T1 : 2.4
7	MIL STD 1553 bus system	CO 1	T1 : 2.5
8	ARINC 429 bus systems	CO 1	T1 : 2.6
9	ARINC 629 bus systems	CO 2	T1 : 2.7
10	Optical data bus systems	CO 2	T1 : 2.9
11	Integrated modular avionics architectures ,	CO 2	T1 : 2.10
12	Commercial off the shelf systems	CO 2	T1 : 2.11
13	Avionics packaging	CO 2	T1 : 2.10
14	Air data sensors.	CO 2	T1 : 3.2
15	magnetic sensing,	CO 2	T1 : 3.3
16	Inertial sensing, radar sensors	CO 2	T1 : 3.4
17	The electromechanical instrumented flight deck	CO 2	T1 : 3.4
18	Early flight deck instruments,	CO 3	T1 : 3.4
19	Attitude direction indicator	CO 3	T1 : 3.4
20	Horizontal situation indicator	CO 3	T1 : 3.4
21	Altimeter	CO 3	T1 : 3.4
22	Airspeed indicator	CO 3	T1 : 3.4
23	Advanced flight deck display system architectures	CO 3	T1 : 4.1
24	Display systems	CO 3	T1 : 4.2
25	Display media	CO 4	T1 : 4.3
26	Future flight deck displays	CO 4	T1 : 4.3
27	Radio frequency spectrum	CO 4	T1 : 4.3
28	Communication systems;	CO 4	T1 : 4.4
29	HF, VHF, satellite communications;	CO 4	T1 : 4.4
30	ATC transponder	CO 5	T2 : 3.3
31	Traffic collision avoidance system;	CO 5	T2 : 3.3
32	Navigational aids	CO 5	T1 : 4.5
33	Automatic direction finding,	CO 5	T1 : 4.5
34	VHF Omni range	CO 5	T1 : 4.5
35	Distance measuring equipment	CO 5	T1 : 4.5
36	TACAN, VORTAC;	CO 6	R1 : 6.1
37	Satellite navigation systems, the GPS.	CO 6	R1 : 6.2
38	Basic navigation, radio, inertial navigations	CO 6	R1 : 6.1.1
39	Satellite navigation;	CO 6	R1 : 6.1.3
40	GPS, differential GPS, wide area augmentation systems,	CO 6	R1 : 6.1.3
PROBLEM SOLVING/ CASE STUDIES			
1	Introduction to avionics, systems integration, need - data bus systems	CO 1	T1 : 2.6
2	Integrated modular avionics architectures	CO 1	T1 : 2.7
3	Commercial off the shelf systems; Avionics packaging.	CO 1	T1 : 3.2
4	The electromechanical instrumented flight deck	CO 2	T1 : 3.1
5	Advanced flight deck display system architectures	CO 2	T2 : 3.3.1

6	Air data sensors	CO 2	R1 : 6.2
7	ATC transponder, traffic collision avoidance system	CO 3	R1 : 6.2
8	Automatic direction finding, VHF Omni range	CO 3	R1 : 6.2
9	Basic navigation, radio, inertial navigations, satellite navigation	CO 4	R1 : 6.2
10	Avionic and mission system interface	CO 5	R1 : 6.2
11	Navigation aids, flight deck displays, communications, aircraft systems	CO 5	R1 : 6.2
12	Command and telemetry.	CO 5	R1 : 6.2
13	Attitude determination and control of spacecraft	CO 6	R1 : 6.2
14	Magnetometers, sun sensors,	CO 6	R1 : 6.2
15	Star trackers, earth and horizon sensors;	CO 6	R1 : 6.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Avionics Technology	CO 1	T1, T2
2	Aircraft Instrumentation - Sensors And Displays	CO 2	T1, T2
3	Communication And Navigation Aids	CO 3, CO 4	T1 R2
4	Military Aircraft Adaptation	CO 5	R2
5	Airborne Radar, Astrionics - Avionics For Spacecraft	CO 6	T1
DISCUSSION OF QUESTION BANK			
1	Avionics Technology	CO 1	T1
2	Aircraft Instrumentation - Sensors And Displays	CO 2	T1
3	Communication And Navigation Aids	CO 3, CO 4	T1, T2
4	Military Aircraft Adaptation	CO 5	R2
5	Airborne Radar, Astrionics - Avionics For Spacecraft	CO 6	R2

Signature of Course Coordinator **HOD, AE**
Mr.K Arun Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**AUTOMATIC CONTROL OF AIRCRAFT**				
Course Code	AAEC52				
Program	B.Tech				
Semester	VIII	AE			
Course Type	PE				
Regulation	UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. Yagya Dutta Dwivedi, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB09	IV	Flight Mechanics
B.Tech	AAEB13	V	Aircraft stability and control

II 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.

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). CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), and 10 marks for Alternative Assessment Tool (AAT).

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
50%	Understand
50%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
	Continuous Internal Examination – 2 (Mid-term)	10	
	AAT-1	5	
	AAT-2	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			100

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in below table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

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 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.

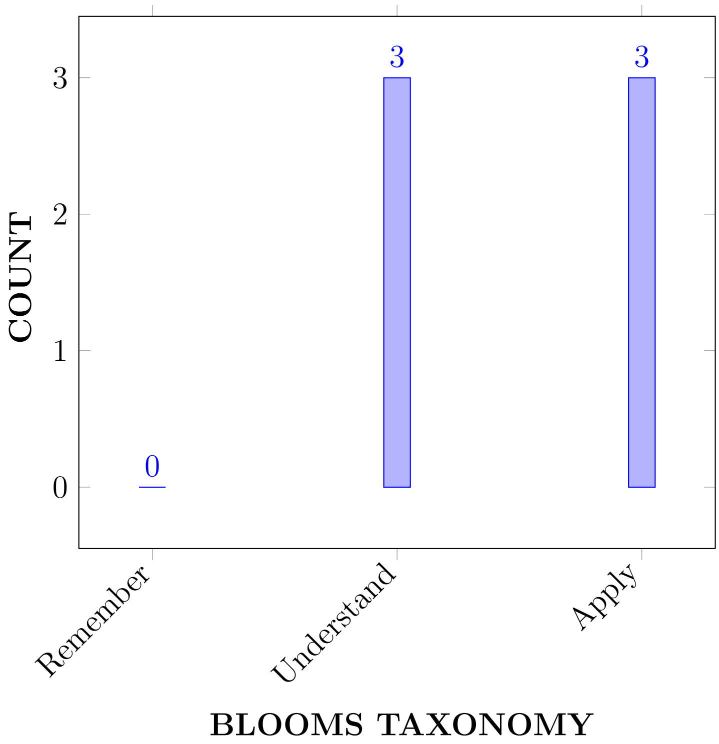
VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the principles of guidance, navigation, and governing laws for the control of aircraft for getting the desired aircraft attitude.	Understand
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	**Summarize** the automatic gain schedule concept for airplane control by plotting the required curve f or obtaining desired automatic control of the flight vehicle.	Understand

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	**Outline** 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.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations

Program Outcomes	
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	CIE/Quiz/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Assignments/ SEE /CIE, AAT, QUIZ

X 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

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	
CO 3	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	-	-	-	-	-	-	-	-		-	✓	-
CO 5	✓	-	-	✓	-	-	-	-	-	-	-	-	-	✓	-
CO 6	✓	✓	-	-	-	-	-	-	-	-	-		-	-	✓

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	**Recollect (knowledge)** the basic concept of static stability and to an extent appreciate (understand) the importance of longitudinal, lateral and directional modes of stability by applying the principles 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

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	Program Outcomes/ No. of Key Competencies Matched												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	6	-	5	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	7	-	-	-	-	-	-	-	-	-		-	2	-
CO 5	2	-	-	5	-	-	-	-	-	-	-	-	-	2	-
CO 6	3	5	-	-	-	-	-	-	-	-	-		-	-	1

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	100	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	60	-	50	-	-	-	-	-	-	-	-	-	-	-
CO 4	67	70	-	-	-	-	-	-	-	-	-		-	67	-
CO 5	67	-	-	50	-	-	-	-	-	-	-	-	-	67	-
CO 6	100	50	-	-	-	-	-	-	-	-	-		-	-	34

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - 0$\leq$ C$\leq$ 5% – No correlation
2 - 40 % <C < 60% –Moderate
1-5 <C$\leq$ 40% – Low/ Slight
3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-		-	-	-
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

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	Concept Video	-	Open Ended Experiments	✓
Assignments	✓	Techtalk	✓		

XVII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVIII 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.

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 OBE, CO-PO Mapping		
DISCUSSION OF COURSE CONTENT			
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	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, Assoc. Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**CSE (AIML)**				
Course Title	**SOFT SKILLS AND INTERPERSONAL COMMUNICATION**				
Course Code	AHSC15				
Program	B.TECH				
Semester	VIII				
Course Type	OPEN ELECTIVE				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3		3	-	-
Course Coordinator	Dr. Srijani Chowdhury, Assistant Professor				

I COURSE PREREQUISITES

Level	Course Code	Semester	Prerequisites
B.Tech	AHSC01	I	Basic principles of soft skills and concepts of functional syntacticalities.

II COURSE OVERVIEW

The objectives of Soft Skills and Interpersonal Communication Skills are to give each student a realistic perspective of work and work expectations. It helps formulate problem solving skills and also it guides students in making appropriate responsible decisions. Besides, it creates a desire to fulfill individual goals, and to educate students about productive thinking, self-defeating emotional impulses, and self- defeating behaviors.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Soft skills and Interpersonal communication	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	X	Assignments	X	MOOC
X	Open Ended Experiments	X	Seminars	X	Mini Project	X	Videos
X	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with" either" or" choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
80%	Understand
20%	Apply
0 %	Analyze
0%	Evaluate
0%	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
	Continuous Internal Examination – 2 (Mid-term)	10	
	AAT-1	5	
	AAT-2	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			100

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

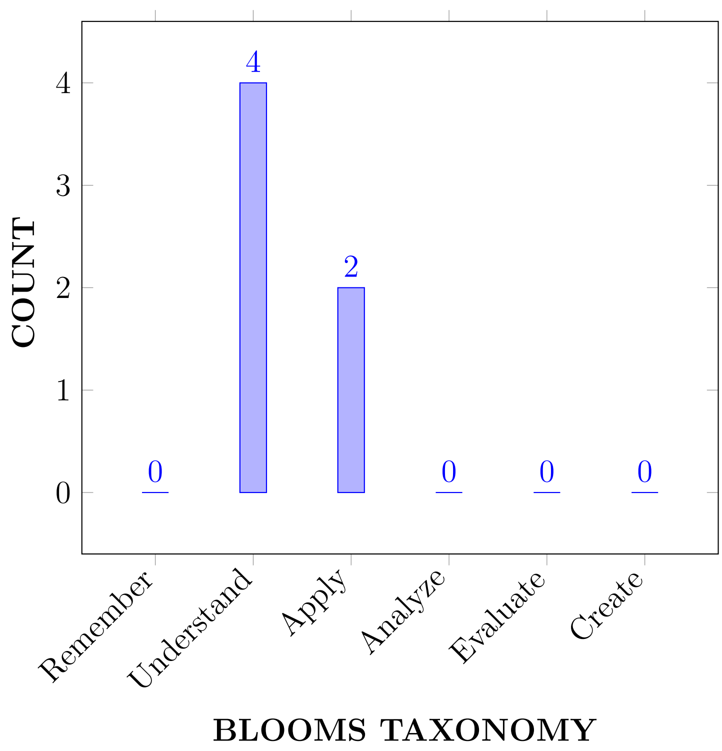
I	Effective communication skills in both spoken and written languages.
II	Well-rounded personalities with a mature outlook, enabling them to function effectively in various formal and informal situations.
III	Self-confidence by mastering inter-personal skills, team management skills, and leadership skills.
IV	Productive presentation skills that provide an advantage when interacting with people at all levels.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Apply** soft skills in the development of personality and use them in their daily life.	Apply
CO 2	**Relate** how to listen actively and respond productively to others.	Understand
CO 3	**Classify** the correct usage of English grammar in reading, writing and speaking.	Understand
CO 4	**Demonstrate** the significance of verbal and non-verbal communication in academic and non-academic platforms.	Understand
CO 5	**Explain** some of the strategies and challenges for developing effective speaking skills and they can be applied to enhance reading skills for understanding the content of advanced-level textbooks and all types of written data.	Understand
CO 6	**Develop** various written communication strategies of cover letter writing, resume writing, E-mail writing and report writing.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO8	**Ethics:**Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (Ethics). 1. **Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior.** 2. **Stood up for what they believed in** 3. **High degree of trust and integrity**	3	Seminar/ Conferences/ Quiz/ AAT Assignments/ Discussion
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. 1. **Clarity (Writing)** 2. **Grammar/Punctuation (Writing)** 3. **References (Writing)** 4. **Speaking (Oral)** 5. **Subject Matter (Oral)**	3	Seminar/ Conferences/ Quiz/ AAT Assignments/ Discussion

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Build skills to develop software applications in specialized areas of Computer Science and Engineering such as Artificial Intelligence, Machine Learning, Data Science, Web Development, Gaming, Augmented Reality / Virtual Reality (AR/VR).	-	-
PSO 2	Focus on exploring supervised, unsupervised and reinforcement learning and apply them to a range of AI problems.	-	-

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 3	Make use of AI and ML techniques for industrial applications in the areas of Autonomous Systems, IOT, Cloud Computing, Robotics, Natural Language Processing and emerging areas.	-	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	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	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-

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XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 8	Identify the basic **professional ethics** of ethical choices, codes of ethics, professional practice, and ethical behaviour with special respect to the usage of soft skills and personality development. Besides, students are designed to **stand up for what they believed in** and they are encouraged to maintain a **high degree of trust and integrity.**	3
CO 2	PO 10	Understand the nuances of spoken communication with **clarity**. Recognize correct **grammatical** structures, vocabulary, and language patterns used by proficient speakers, thereby enhancing their own **speaking** proficiency.	5
CO 3	PO 10	Interpret how proper **grammar** contributes to clear communication, both in **written** and **oral** contexts and also demonstrate the apt applicability of different rules of grammar in **oral** presentations with **clarity.**	5
CO 4	PO 8	Infer the essential roles of verbal and nonverbal communication in expressing **ethical choices, discussing codes of ethics, evaluating ethical dimensions, demonstrating ethical behavior, standing up for beliefs, and maintaining trust and integrity within professional contexts.**	3
CO 4	PO10	Extend the knowledge on **subject matter** with appropriate **clarity** using with proper **grammatical** structures in both areas of **speaking** and **written** communication practices.	5

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 5	PO 8	Extend effective speaking skills while applying ethical principles and committing to professional ethics in the field of engineering.	3
CO 5	PO 10	Understand how strong speaking skills play a crucial role in the ability to articulate complex ideas clearly and concisely, enabling effective communication about intricate engineering activities with both the engineering community and society at large.	5
CO 6	PO 10	Classify different **oral** and **written** communication strategies through systematic order and also recognize appropriate method in order to understand the writer's point of view with **clarity** while **reading** and practices proper **grammatical** functionalities to understand different **subject matters.**	5

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-
CO 2	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	3	-	5	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	3	-	5	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-
CO 2	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	100	-	100	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	100	-	100	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-
CO 2	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	3	-	3	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	3	-	3	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
TOTAL								9		15			-	-	-
AVERAGE								3		3			-	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	10 Minutes Video	✓	Open Ended Experiments	✓
Assignments	✓				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback
✓	Early Semester Feedback		

XVIII SYLLABUS:

MODULE I	**SOFT SKILLS**
	Soft Skills: An Introduction – Definition and significance of soft skills; Process, Importance and application of soft skills, discovering the self; setting goals; positivity and motivation: developing positive thinking and attitude
MODULE II	**EFFECTIVENESS OF SOFT SKILLS**
	Developing interpersonal relationships through effective soft skills; Define Listening, Speaking, Reading and Writng skills; Barriers to Listening, Speaking, Reading and Writing; Essential formal writing skills; Public Speaking: Skills, Methods, Strategies and Essential tips for effective public speaking.
MODULE III	**ORAL AND AURAL SKILLS**
	Sounds of English vowels sounds and consonant sounds, Word Accent and connected speech- contractions, questions tags, Listening for information, Taking notes while listening to lectures (use of Dictionary). Group Discussion: Importance, Planning, Elements, Skills, Effectively disagreeing, Initiating
MODULE IV	**VERBAL AND NON-VERBAL COMMUNICATION**

	Interpersonal communication-verbal and nonverbal etiquette; Body language, grapevine, Postures, Gestures, Facial expressions, Proximity; Conversation skills, Critical thinking, Teamwork, Group Discussion, Impact of Stress; Measurement and Management of Stress
MODULE V	**WRITTEN COMMUNICATION**
	Significance; Effectiveness of writing; Organizing principles of Paragraphs in documents; Writing introduction and conclusion; Techniques for writing precisely; Letter writing; Formal and Informal letter writing; E-mail writing, Report Writing.

TEXTBOOKS

1. Raman Meenakshi, Upadhyay Shalini (2017). Soft Skills: Key to Success in Workplace and Life. Cengage India Private Limited, Noida.

2. Handbook of English for Communication (Prepared by Faculty of English, IARE)

REFERENCE BOOKS:

1. Dorch, Patricia. What Are Soft Skills? New York: Execu Dress Publisher, 2013.

2. Klaus, Peggy, Jane Rohman & Molly Hamaker. —The Hard Truth about Soft Skill, London: HarperCollins E-books, 2007.

3. Kamin, Maxine. Soft Skills Revolution: A Guide for Connecting with Compassion for Trainers, Teams, and Leaders. Washington, DC: Pfeiffer & Company, 2013.

4. Stein, Steven J. & Howard E. Book. —The EQ Edge: Emotional Intelligence and Your Success Canada: Wiley & Sons, 2006

5. Suresh Kumar. English for Success. Cambridge University Press IndiaPvt.Ltd.2010.

6. Dorling Kindersley. Communication Skills & Soft Skills - An Integrated Approach. India Pvt. Ltd. 2013.

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1. https://nptel.ac.in/courses/112105171/1

2. www.edufind.com

3. www.myenglishpages.com

4. http://grammar.ccc.comment.edu

5. http://owl.english.prudue.edu

E-TEXT BOOKS:

1. http://bookboon.com/en/communication-ebooks-zip

2. http://www.bloomsbury-international.com/images/ezone/ebook/writing-skills-pdf.pdf

3. http://learningenglishvocabularygrammar.com/files/idiomsandphraseswith meaningsandexamplespdf.pdf

4. http://www.robinwood.com/Democracy/General Essays/CriticalThinking.pdf

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Discussion on mapping COs with POs (OBE)		T1:06.06
CONTENT DELIVERY (THEORY)			
2	Introduction of soft skills	CO1	T1:06.09
3	Significance of soft skills..	CO1	T1:09.10
4	Process, importance and application of soft skills..	CO1	T1:08:05
5	Discovering one's self-qualities.	CO1	T1:06:02
6	Setting up goals	CO1	T1:04:74
7	Positivity and motivation.	CO1	T1:01:08
8	Developing one's positive thinking and attitude	CO 1	T1:03:01
9	Developing interpersonal relationships through soft skills..	CO2	T1:06:05
10	Significance of listening skills.	CO 2	T1:02:09
11	Significance of speaking skills.	CO 4	T1:26:11
12	Significance of reading skills..	CO 5	T1:46:08
13	Significance of writing skills.	CO 6	T1:16:20
14	Barriers to listening and speaking.	CO 2	T1:13:43
15	Barriers to reading and writing.	CO 5	T1:40:51
16	Essentials of formal writing skills.	CO 6	T1:19:07
17	Developing public speaking skills.	CO4	T1:69:62
18	Methods, strategies of public speaking..	CO 4	T1:5:05
19	Essential tips for effective public speaking.	CO4	T1:46:05
20	Introduction to sounds of vowels and consonants.	CO 4	T1:09:18
21	Contractions and questions tags.	CO 3	T1:07:14
22	Listening for information.	CO 1	T1:32:96
23	Taking notes while listening to lectures.	CO 3	T1:55:21
24	Group discussion and its importance.	CO 2	T1:14:25
25	Planning, elements, skills, effectively, disagreeing, initiating.	CO 2	T1:08:08
26	Developing interpersonal communication skills.	CO4	T1:22:74
27	The role of verbal and nonverbal etiquettes in one's career.	CO1	T1:32:36
28	Significance of body language,	CO 1	T1:78:12
29	Grapevine communication.	CO4	T1:01:08
30	Developing critical thinking.	CO4	T1:04:18
31	Conversation skills at formal and informal situations. .	CO4	T1:06:08
32	The power of group discussion and the role of a team work.	CO4	T1:03:22
33	Impact of stress; measurement and management of stress.	CO4	T1:89:01
34	Significance and effectiveness of writing.	CO 6	T1:01:04
35	Organizing principles of paragraphs in documents;	CO 4	T1:74:32
36	Writing introduction and conclusion	CO 1	T1:25:10
37	Techniques for writing precisely;	CO 6	T1:09:07

38	Letter writing; Formal and Informal letter writing;	CO 6	T1:60:31
39	Rules of E-mail writing.	CO 6	T1:22:12
40	Strategies of report writing.	CO 6	T1:01:01
41	Persuasive writing techniques.	CO 6	T1:01:02
	PROBLEM SOLVING/ CASE STUDIES		
42	Soft skills can help someone come out of difficult situations and ensure reassurance along with reliability. think critically and answer	CO 1	R2:7.5
43	Will not hard skills suffice the requirement needed in a corporate setup without soft skills?	CO 1	R2:7.5
44	Do you think soft skills are communication skills? If so, give your reasons	CO 1	R2:7.5
45	Describe the way interpersonal communication can influence the psychological health of individuals with examples.	CO 1	R2:7.5
46	What do you mean by 'assumption' in the communication process and explain with a real -life example?	CO 1	R2:7.5
47	Explain with examples the self-fulfillment and happiness of productive interpersonal communication skills.	CO 1	R2:7.5
48	Explain the importance of learning the sounds of English language for fluent and confident communication.	CO 3	R2:7.5
49	Mispronunciation of English words may lead to miscommunication and misconception. Elaborate with the help of an example.	CO 3	R2:7.5
50	Throw light on word stress which is pivotal for proper differentiation of sounds.	CO 3	R2:7.5
51	Differentiate between verbal and non-verbal communication	CO 4	R2:7.5
52	Classify non-verbal skills and explain the various skills that are important	CO 4	R2:7.5
53	Write down advantages of non-verbal skills	CO 4	R2:7.5
54	What is the meaning of thesis focus? Explain in detail.	CO 6	R2:7.5
55	What do you understand by organization?	CO 6	R2:7.5
56	Support and Elaboration is an extension and development of the topic/subject/ thesis. Comment.	CO 6	R2:7.5
	DISCUSSION OF DEFINITION AND TERMINOLOGY		
57	Definition and terminology of soft skills	CO 1	T1:69:08
58	Definition and terminology of contractions	CO 3	T1:65:66
59	Definition and terminology of question tags	CO 3	T1:42:03
60	Definition and terminology of verbal and nonverbal communication	CO 4	T1:78:78
61	Definition and terminology of self discovery	CO 1	T1:09:01

DISCUSSION OF QUESTION BANK			
62	Module I - Soft skills and interpersonal communication	CO 1	R4:2.1
63	Module II - Effectiveness of soft skills	CO 2	T4:7.3
64	Module III - Oral and aural skills	CO 3,4	R4:5.1
65	Module IV - Verbal and nonverbal communication	CO 5	T1:7.5
66	Module V - Interpersonal communication	CO 6	T1: 4.1

Signature of Course Coordinator **HOD**

Dr. Srijani Chowdhury. Assistant Professor.