INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**COMPUTER SCIENCE AND ENGINEERING**				
Course Title	**ENGINEERING CHEMISTRY**				
Course Code	**AHSB03**				
Program	**B.Tech**				
Semester	**I**				
Course Type	**FOUNDATION**				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	3	1.5
Course Coordinator	Dr V Anitha Rani, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
10+2	-	-	Vital principles of chemistry

II COURSE OVERVIEW:

The concepts developed in this course will aid in quantification of several concepts in chemistry that have been introduced at the Intermediate level. Technology is being increasingly based on the electronic, atomic and molecular level modifications. Quantum theory is more than 100 years old and to understand phenomena at nanometer levels; one has to base the description of all chemical processes at molecular levels.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Engineering Chemistry	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 SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE UNITs and each UNIT carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with either or choice will be drawn from each UNIT. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE UNITs and each UNIT carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each UNIT. 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
0%	Evaluate
0 %	Create

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

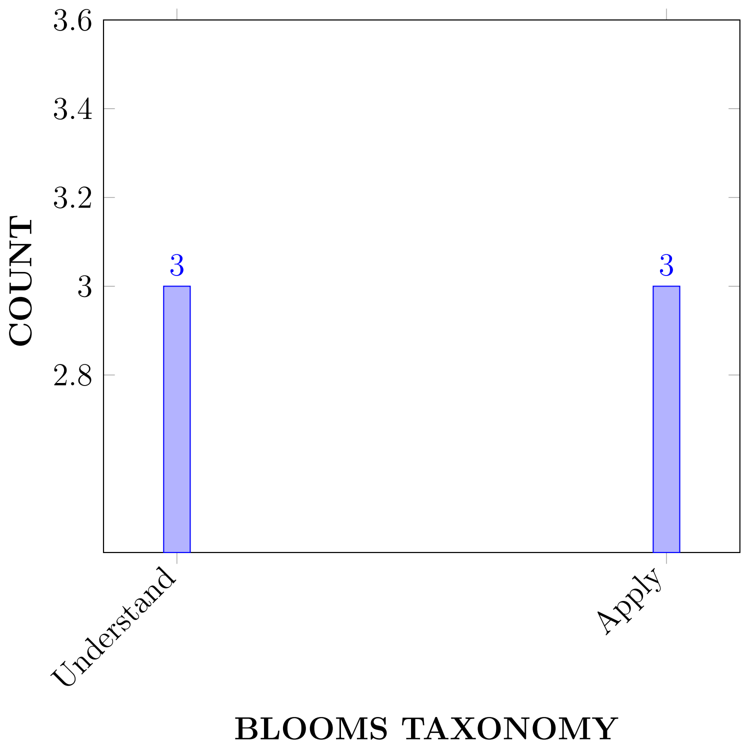
I	The concepts of electrochemical principles and causes of corrosion in the new development and breakthroughs efficiently in engineering and technology.
II	The different parameters to remove causes of hardness of water and their reactions towards the complexometric method.
III	The microscopic chemistry in terms of atomic, molecular orbitals and Intermolecular forces.
IV	The different molecular organic chemical reactions that are used in the synthesis of molecules.
V	The properties, separation techniques of natural gas and crude oil along with potential applications in major chemical reactions.

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	**Illustrate** the molecular orbital energy level diagrams of different molecules and theories of bonding for understanding the magnetic properties of coordination compounds.	Understand
CO 5	**Explain** the mechanism of different chemical reactions, stereo isomers for finding the optically active compounds and synthesizing the drug molecules.	Understand
CO 6	**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

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.	2.5	SEE/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	SEE/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	SEE/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	Explain the electrochemical properties for producing electrical energy (understand) 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
CO3	PO1	Explain the concept of corrosion processes in metals by exposing to acidic environment for solving engineering problems by applying the principles of science	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO2	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
CO4	PO1	Explain the formation of molecular orbitals by linear combination of atomic orbitals, splitting of d orbitals for formation of octahedral, tetrahedral and square planar complexes for solving engineering problems by applying the principles of science.	2
CO5	PO1	Illustrate the structural and stereo isomers of optically active compounds, different types of molecular organic reactions for synthesizing drugs by using principles of science for solving engineering problems.	2
CO6	PO1	Classify different types of solid, liquid and gaseous fuels with their characteristics and calorific value by using principles of science and mathematics for solving engineering problems.	3
	PO2	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
	PO7	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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	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	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	20.0	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	20.0	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	20.0	-	-	-	-	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
1 - $5 < C \leq 40\%$ – Low/ Slight
2 - $40\% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	5 minutes video	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	-	-	-	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

UNIT I	**ELECTROCHEMISTRY AND BATTERIES**
	Electro chemical cells: Electrode potential, standard electrode potential, types of electrodes; Calomel, Quinhydrone and glass electrode; Nernst equation; Electrochemical series and its applications; Numerical problems; Batteries: Primary (Dry cell) and secondary batteries (Lead-acid storage battery and Lithium ion battery). Causes and effects of corrosion: Theories of chemical and electrochemical corrosion, mechanism of electrochemical corrosion; Types of corrosion: Galvanic, water-line and pitting corrosion; Factors affecting rate of corrosion; Corrosion control methods: Cathodic protection, sacrificial anode and impressed current; Surface coatings: Metallic coatings- Methods of coating- Hot dipping, cementation, electroplating and Electroless plating of copper.
UNIT II	**CORROSION AND ITS CONTROL**
	Corrosion: Introduction, causes and effects of corrosion; Theories of corrosion: Chemical and electrochemical corrosion with mechanism; Factors affecting the rate of corrosion: Nature of the metal and nature of the environment; Types of corrosion: Waterline and crevice corrosion; Corrosion control methods: Cathodic protection- sacrificial anodic protection and impressed current cathodic protection; Surface coatings: Metallic coatings, methods of application of metallic coatings-hot dipping(galvanizing, tinning), electroplating(copper plating); Organic coatings: Paints, its constituents and their functions
UNIT III	**WATER TECHNOLOGY**
	Water: Sources and impurities of water, hardness of water, expression of hardness-units; Types of hardness: Temporary hardness, permanent hardness and numerical problems; Estimation of temporary and permanent hardness of water by EDTA method; Determination of dissolved oxygen by Winkler's method; Boiler troubles: Priming, foaming, scales, sludges and caustic embrittlement. Treatment of water: Internal treatment of boiler feed water- carbonate, calgon and phosphate conditioning, softening of water by Zeolite process and Ion exchange process; Potable water-its specifications, steps involved in the treatment of potable water, sterilization of potable water by chlorination and ozonization, purification of water by reverse osmosis process.
UNIT IV	**MATERIALS CHEMISTRY**
	Materials chemistry: 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; Rubbers: Natural rubber its process and vulcanization; Elastomers: Buna-s and Thiokol rubber; Fibers: Characteristics of fibers, preparation properties and applications of Dacron; Characteristics of fiber reinforced plastics; Cement: Composition of Portland cement, setting and hardening of Portland cement; Lubricants: Classification with examples; Properties: Viscosity, flash, fire, cloud and pour point; Refractories: Characteristics and classification with examples..

UNIT V	**FUELS AND COMBUSTION**
	Fuel: Definition, classification of fuels and characteristics of a good fuels; Solid fuels: Coal; Analysis of coal: Proximate and ultimate analysis; Liquid fuels: Petroleum and its refining; Cracking: Fixed bed catalytic cracking; Knocking: Octane and cetane numbers; Gaseous fuels: Composition, characteristics and applications of natural gas, LPG and CNG; Combustion: Calorific value: Gross Calorific Value(GCV) and Net Calorific Value(NCV), calculation of air quantity required for complete combustion of fuel, numerical problems.

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. R.T. Morrison, RN Boyd and SK Bhattacharya, “Organic Chemistry”, Pearson, 7th Edition, 2011
4. K.F. Purcell and J.C. Kotz, “Inorganic Chemistry”, Cengage learning, 2017.

REFERENCE BOOKS:

1. K. P. C. Volhardt and N. E. Schore, “Organic Chemistry Structure and Functions”, Oxford Publications, 7th Edition 2010.
2. B. H. Mahan, “University Chemistry”, Narosa Publishers, 4th Edition, 2009.

WEB REFERENCES:

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

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO’s	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	Concept of Electro chemical cells	CO1	T1,T2
3	Numerical problems on EMF: Galvanic Cells	CO 2	T1,T2
4	Types of Electrodes: Calomel, Quinhydrone and Glass electrode	CO 2	T1,T2
5	Nernst equation and its applications	CO 2	T1,T2
6	Batteries: Primary cells (dry cells)	CO 1	T1,T2
7	Secondary cells (lead-Acid cell). Applications of batteries	CO 1	T1,T2
8	Corrosion-Definition ,Causes and effects of corrosion, Theories of corrosion – Chemical corrosion theory	CO 1	T1,T2

9	Types of corrosion (water line and pitting), Factors affecting rate of corrosion	CO 1	T1,T2
10	Corrosion control methods – Cathodic protection and metallic coating.	CO 1	T1,T2
11	Hardness of water, expression of hardness-units; Types of hardness: Temporary hardness, permanent hardness and numerical problems.	CO 3	T1,T2
12	Estimation of temporary and permanent hardness of water by EDTA	CO 3	T1,T2
13	Potable water and its specifications, steps involved in its treatment of water.	CO 3	T1,T2
14	Boiler troubles – Priming and foaming, caustic embrittlement	CO 3	T1,T2
15	Treatment of boiler feed water – Internal treatment (Phosphate, carbonate and calgon conditioning)	CO 3	T1,T2
16	Ion exchange process, steps involved in the treatment of this process	CO 3	T1,T2
17	Sterilization of potable water by chlorination and ozonization	CO 3	T1,T2
18	purification of water by reverse osmosis process. Numerical problems	CO 3	T1,T2
19	Shapes of Atomic Orbitals	CO 4	T1,T2
20	Linear combination of Atomic orbitals (LACO)	CO 4	T1,T2
21	Molecular orbitals of diatomic molecules N2 O2 and F2.	CO 4	T1,T2
22	Molecular orbitals diatomic CO and NO molecule	CO 4	T1,T2
23	Crystal Field Theory (CFT), Salient Features of CFT-Crystal Fields	CO 4	T1,T2
24	Splitting of transition metal ion d- orbitals in Tetrahedral	CO 4	T1,T2
25	Splitting of transition metal ion Octahedral and square planar geometries	CO 4	T1,T2
26	Band structure of solids and effect of doping on conductance	CO 4	T1,T2
27	Introduction to representation of 3-dimensional structures	CO 5	T1,T2
28	Structural and stereoisomers of organic compounds	CO 5	T3
29	Configurations, symmetry and chirality.	CO 5	T3
30	Enantiomers, diastereomers, optical activity and Absolute configuration	CO 5	T3
31	Conformation alanalysis of n- butane	CO 5	T3
32	Nucleophilic substitution reactions, Mechanism of SN1, SN2 reactions	CO 5	T3
33	Electrophilic and nucleophilic addition reactions; Addition of HBr to Propene; Markownikoff and anti Markownikoff's additions	CO 5	T3
34	Grignard additions on carbonyl compounds, EliminationreactionsDehydro halogenations of alkylhalides	CO 5	T3
35	Oxidation reactions: Oxidation of alcohols using KMnO4 and chromicacid.	CO 5	T3
36	Reduction reactions: Reduction of carbonyl compounds using LiAlH4& NaBH4	CO 5	T3

37	Hydroboration of olefins	CO 5	T3
38	Structure, synthesis and pharmaceutical applications of Paracetamol and Aspirin.		T3
39	Definition, classification of fuels and characteristics of a good fuels	CO 5	T1,T2
40	Solid fuel Coal, analysis of coal- proximate analysis	CO 6	T1,T2
41	Analysis of coal -ultimate analysis.	CO 6	T1,T2
42	Liquid fuels: Petroleum and its refining Cracking: Fixed bed catalytic cracking;	CO 6	T1,T2
43	Knocking: Octane and cetane numbers	CO 6	T1,T2
44	Gaseous fuels: Composition, characteristics and applications of Natural gas, LPG and CNG	CO 6	T1,T2
45	Combustion: Calorific value-Gross calorific value(GCV) and net calorific value(NCV)	CO 6	T1,T2
46	Calculation of air quantity required for complete combustion of fuel, numerical problems.	CO 6	T1,T2
PROBLEM SOLVING			
1	Probelms on EMF	CO 1	T1:3.3.1; R3:3.2
2	Probelms on Nernst equation	CO 1	T2:16.5; R3:8.10
3	Determination of Electrode potential	CO 2	T2:16.5; R3:8.10
4	Determination of Hardness	CO 3	T1:3.3.1; R3:3.2
5	Determination of Hardness by EDTA	CO 3	T2:16.5; R3:8.10
6	Crystal field stabalization energy	CO 4	T2:16.5; R3:8.10
7	Proximate Analysis of coal	CO 6	T1:3.3.1; R3:3.2
8	ultimate Analysis of coal	CO 6	T2:16.5; R3:8.10
9	Dulungs Equation for coal analysis	CO 6	T2:16.5; R3:8.10
10	Probelms on Combustion	CO 6	T1:3.3.1; R3:3.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Electro Chemistry and Batteries	CO 1	T2:16.5; R3:8.10
2	Water and Its Treatment	CO 2	T1:3.3.1; R3:3.2
3	Molecular Structure and Theories of Bonding	CO 3	T2:16.5; R3:8.10
4	Streo chemistry,Reaction Mechanisim	CO 4	T2:16.5; R3:8.10

5	Fuels and Combustion	CO 6	T2:16.5; R3:8.10
DISCUSSION OF QUESTION BANK			
1	Electro Chemistry and Batteries	CO 1	T2:16.5; R3:8.10
2	Water and Its Treatment	CO 2	T1:3.3.1; R3:3.2
3	Molecular Structure and Theories of Bonding	CO 3	T2:16.5; R3:8.10
4	Streo chemistry,Reaction Mechanisim	CO 4	T2:16.5; R3:8.10
5	Fuels and Combustion	CO 6	T2:16.5; R3:8.10

Signature of Course Coordinator **HOD,CSE**

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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**ENGINEERING DRAWING**				
Course Code	AME001				
Program	B.Tech				
Semester	I				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	-	4	3	4
Course Coordinator	Prof. B.V.S.N.Rao, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
+2	-	-	Basics of Geometry

II COURSE OVERVIEW:

One of the best ways to communicate one's ideas is through some form of picture or drawing. This is especially true for the engineer. An engineering drawing course focuses on usage of drawing instruments, lettering, construction of geometric shapes, etc. Students study use of dimensioning, shapes and angles or views of such drawings. Dimensions feature prominently, with focus on interpretation, importance and accurate reflection of dimensions in an engineering drawing. Other areas of study in this course may include projected views, pictorial projections and development of surfaces. This course also gives basic concepts for studying machine drawing, building drawing, circuit drawings etc.

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

The SEE is conducted for 70 marks of 3 hours duration. The question paper pattern is as follows: two full questions with 'either' 'or' choice will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question. All the drawing related courses are evaluated in line with laboratory courses. The distribution shall be 30 marks for internal evaluation (20 marks for day–to–day work, and 10 marks for internal tests) and 70 marks for semester end lab examination. There shall be ONE internal test for 10 marks in each semester.
The emphasis on the questions is broadly based on the following criteria:
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

50%	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

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:

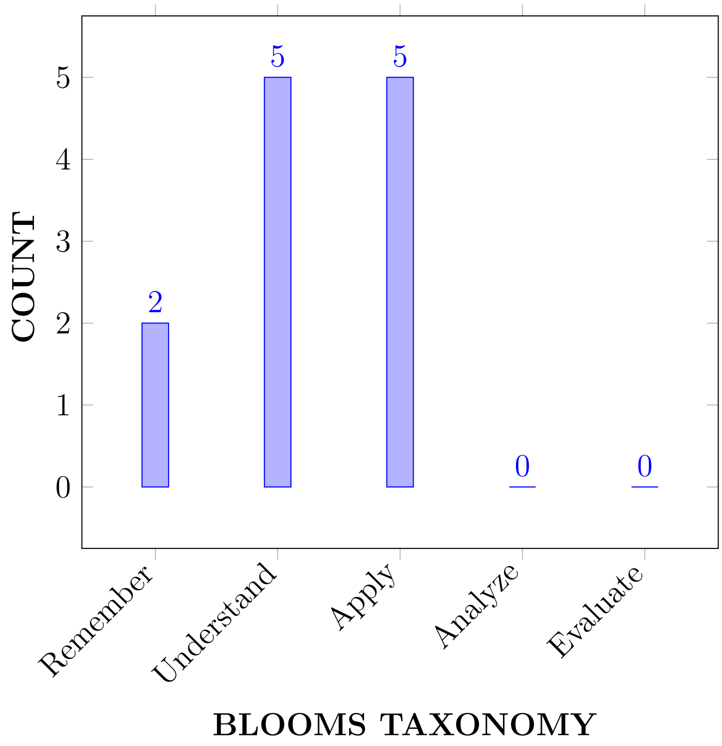
I	Understand the basic principles of engineering drawing and construction of curves used in engineering field
II	Apply the knowledge of interpretation of projection in different quadrants
III	Understand the projections of solids, when it is inclined to both planes simultaneously
IV	Convert the pictorial views into orthographic view and vice versa
IV	Create intricate details of components through sections and develop its surfaces

VII COURSE OUTCOMES:

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

CO 1	**Demonstrate** the instruments used in engineering drawing, conventional representations and placing dimensions for **producing flawless drawings in engineering applications**	Understand
CO 2	**Make use of** principles of orthographic projections for the representation **of three dimensional objects on a plane used in engineering field**	Apply
CO 3	**Draw** the isometric projection of three dimensional objects **for visualization of shape and size of the objects.**	Understand
CO 4	**Draw** the development of surfaces of regular solids and their cut sections **used in sheet metal work for making industrial needs.**	Understand
CO 5	**Visualize** the components by isometric projection by representing three dimensional objects in two dimensions **in technical and engineering drawings.**	Understand
CO 6	**Convert** the orthographic views into pictorial views and vice-versa **for designing and manufacturing of components in industries.**	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	**Professional Skills:** To produce engineering professional capable of synthesizing and analyzing mechanical systems including allied engineering streams	1	Assignments

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	**Problem solving skills:** An ability to adopt and integrate current technologies in the design and manufacturing domain to enhance the employability.	-	Assignments
PSO 3	**Successful career and Entrepreneurship:** To build the nation, by imparting technological inputs and managerial skills to become technocrats.	-	-

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

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

COURSE OUTCOMES	**PROGRAM OUTCOMES**												**PSO'S**		
	PO 1	PO 2	PO 3	PO 4	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	-	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 3	3	-	1	-	-	-	-	-	-	2	-	-	-	-	-
CO 4	3	-	2	-	-	-	-	-	-	2	-	2	2	-	-
CO 5	3	-	2	-	-	-	-	-	-	2	-	2	2	-	-
CO 6	3	-	2	-	-	-	-	-	-	2	-	-	1	-	-
TOTAL	18	-	7	2	-	-	-	-	-	9	-	4	5	-	-
AVERAGE	3	-	1.75	-	-	-	-	-	-	1.8	-	2	1.67	-	-

XV ASSESSMENT METHODOLOGY-DIRECT:

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

XVI ASSESSMENT METHODOLOGY-INDIRECT:

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

XVII SYLLABUS:

MODULE I	**FUNDAMENTALS OF ENGINEERING DRAWING, SCALES AND CURVES**
	Introduction to engineering drawing: Drawing instruments and accessories, types of line, lettering practice and rules of dimensioning, geometrical constructions, basic geometrical shapes; Scales: Types of scales, units of length and their conversion, construction of scales, plain scale, diagonal scale, vernier scale; Curves used in engineering practice and their constructions; Conic sections, construction of ellipse parabola and hyperbola, special curves, construction of cycloid, epicycloids, hypocycloid and involutes
MODULE II	**ORTHOGRAPHIC PROJECTION, PROJECTION OF PLANES**

	Orthographic projection: Principles of orthographic projections, conventions, first and third angle projections, projection of points, projection of lines, lines inclined to single plane, lines inclined to both the planes, true lengths and traces; Projection of planes: Projection of regular planes, planes inclined to one plane, planes inclined to both planes, projection of planes by auxiliary plane projection method.
MODULE III	**PROJECTION OF SOLIDS**
	Projection of solids: Projections of regular solid, prisms, cylinders, pyramids, cones. Solids inclined to one plane, solids inclined to both planes, projection of solid by auxiliary Page — 5 plane projection method.
MODULE IV	**DEVELOPMENT OF SURFACES, ISOMETRIC PROJECTIONS**
	Development of surfaces: Development of lateral surface of right regular solids, prisms, cylinders, pyramids and cones; Isometric projections: Principle of isometric projection, isometric scale, isometric projections and isometric views, isometric projections of planes, prisms, cylinders, pyramids, and cones
MODULE V	**TRANSFORMATION OF PROJECTIONS**
	Transformation of projections: Conversion of isometric views to orthographic views and conversion of orthographic views to isometric views..

TEXTBOOKS

1. N. D. Bhatt, "Engineering Drawing", Charotar Publications, 49thEdition, 2012.
2. C. M. Agrawal, Basant Agrawal, "Engineering Drawing", Tata McGraw Hill, 2ndEdition, 2013.

REFERENCE BOOKS:

1. K.Venugopal, "Engineering Drawing and Graphics", New Age Publications, 2ndEdition, 2010
2. K. C. John, "Engineering Drawing", PHI Learning Private Limited", 2nd Edition, 2009.
3. Dhananjay. A. Johle, "Engineering Drawing", Tata McGraw Hill, 1st Edition, 2008

WEB REFERENCES:

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

Signature of Course Coordinator **HOD,ME**
Prof. B.V.S.N.Rao, Professor

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

COURSE DESCRIPTION

Department	**CIVIL ENGINEERING**				
Course Title	**ENVIRONMENTAL STUDIES**				
Course Code	AHS009				
Program	B.Tech				
Semester	II				
Course Type	FOUNDATION				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr V Anitha Rani, Associate Professor				

I COURSE PRE-REQUISITES:

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

II COURSE OVERVIEW:

Environmental study is interconnected interrelated and interdependent subject. Hence, it is multidisciplinary in nature. The present course is framed by expert committee of UGC under the direction of honorable supreme court to be as a core module syllabus for all branches of higher education and to be implemented in all universities over India. The course is designed to create environmental awareness and consciousness among the present generation to become environmental responsible citizens. The course description is multidisciplinary nature of environmental studies, natural resources Renewable and non-renewable resources Ecosystems Biodiversity and its conservation Environmental pollution Social issues and the environment Human population and the environment Pollution control acts and field work. The course is divided into five chapters for convenience of academic teaching followed by field visits.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Environmental Studies	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 1), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

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 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 section XI.

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	The interrelationship between living organism and environment.
II	The importance of environment by assessing its impact on the human world
III	The knowledge on themes of biodiversity, natural resources, pollution control and waste management.
IV	The constitutional protection given for the safety of environment.

VII COURSE OUTCOMES:

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

CO 1	**Explain** the basic concept of environment, earths major cycle and its function related food chain, food web, and ecological pyramid for the importance of ecosystem and flow of energy in ecosystem	Understand
CO 2	**Classify** natural resource and necessity of natural resource conservationfor sustainable use and proper use.	Understand
CO 3	**Utilize** renewable and non-renewable energy resource for future growing energy needs.	Apply
CO 4	**Explain** the value of biodiversity hotspots, endangered and endemic species, in- situ and ex situ conservation methods for protecting the biodiversity.	Apply
CO 5	**Relate** the cause and effects of pollution related to Air, Water, Soil and Noise their control and treatment technologies.	Understand
CO 6	**Summarize** the concepts of Environmental Impact Assessment, global environmental problem, international summits, to minimize the problems towards sustainable future.	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.	2	CIE/Quiz/AAT
PO 4	**Conduct investigations of complex problems:**Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	CIE/Quiz/AAT
PO 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/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	**Professional Skills:** The ability to understand, analyze and develop computer programs in the areas related to algorithms, system software, multimedia, web design, big data analytics, and networking for efficient design of computer-based systems of varying complexity	-	-
PSO 2	**Problem-Solving Skills:** The ability to apply standard practices and strategies in software project development using open-ended programming environments to deliver a quality product for business success.	-	-
PSO 3	**Successful Career and Entrepreneurship:** The ability to employ modern computer languages, environments, and platforms in creating innovative career paths to be an entrepreneur, and a zest for higher studies.	-	-

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 basic concept of environment, earths major cycle and its function related food chain, food web, and ecological pyramid for the importance of ecosystem and flow of energy in ecosystem by using principles of science for solving engineering problems.	2
	PO 7	Summarize about the toxicity of heavy metals on the biotic and abiotic components in in socio economic Environmental and politics contexts for Sustainable development.	3
CO 2	PO 1	Classify about different types of natural resources and their applicability and illustrate the utility of renewable resources efficiency by using principles of science for solving engineering problems.	2
	PO 7	Identify renewable and non renewable resources, Alternate energy resources and understand the impact in socio economic Environmental and politics contexts for Sustainable development.	3
CO3	PO 1	Explain the renewable and non renewable energy resource by using principles of science for solving engineering problems.	2
	PO 7	Utilize renewable and non renewable resources, Alternate energy resources and understand the impact in socio economic, politics and Environmental contexts for Sustainable development.	3
CO4	PO 1	Explain the fundamentals of Biodiversity and biotic resources, importance of biodiversity, the ecological values, India is mega diversity nation, the threats to biodiversity and importance of conservation of biodiversity by applying the principle of science for solving engineering problems.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 7	Demonstrate a comprehensive understanding of the world's biodiversity and the importance of its conservation, impact of biodiversity loss and National biodiversity act with the in socio economic, politics and Environmental contexts for Sustainable development.	3
CO5	PO 1	Relate the 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	Explain the causes and effects of air pollution, water pollution, soil pollution and noise pollution and understand the impact in socio economic, politics and environmental contexts for sustainable development.	3
CO 6	PO 1	Explain the concepts of environmental impact assessment, global environmental problems, international summits, to minimize the problems towards sustainable future for solving engineering problems by applying the principles of science.	2
	PO 4	Recognize the methods and process of primary, secondary and tertiary treatment of waste water and understand the technology behind the pollution control devices.	2
	PO 7	Identify the environmental laws, population and its explosion green buildings in the context in socio economic, politics and Environmental contexts for Sustainable development.	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	2	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 3	2	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 5	2	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 6	2	-	-	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	66.6	-	-	-	-	-	100	-	-	-	-	-	-	-	-
CO 2	66.6	-	-	-	-	-	100	-	-	-	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 3	66.6	-	-	-	-	-	100	-	-	-	-	-	-	-	-
CO 4	66.6	-	-	-	-	-	100	-	-	-	-	-	-	-	-
CO 5	66.6	-	-	-	-	-	100	-	-	-	-	-	-	-	-
CO 6	66.6	-	-	18	-	-	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	-	-	-	-	-	-	-	
CO 2	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 6	3	-	-	1	-	-	3	-	-	-	-	-	-	-	-
TOTAL	18	-	-	1	-	-	18	-	-	-	-	-	-	-	-
AVERAGE	3	-	-	1	-	-	3	-	-	-	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓	Seminars	✓
Concept Video	-	Mini Project	-	Student Viva	-	Mini Project	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**ENVIRONMENT AND ECOSYSTEMS**
	Environment: Definition, scope and importance of environment, need for public awareness; Ecosystem: Definition, scope and importance of ecosystem, classification, structure and function of an ecosystem, food chains, food web and ecological pyramids, flow of energy; Biogeochemical cycles Hydrological cycle, Phosphorous cycle, Nitrogen cycle. Biomagnifications.
MODULE II	**NATURAL RESOURCES**
	INatural 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; Mineral resources: Use and exploitation; Land resources; Energy resources: Growing energy needs, renewable and non renewable energy sources, use of alternate energy source, case studies.
MODULE III	**BIODIVERSITY AND BIOTIC RESOURCES**
	Biodiversity and biotic resources: Introduction, definition, genetic, species and ecosystem diversity; Value of biodiversity: Consumptive use, productive use, social, ethical, aesthetic and optional values; India as a mega diversity nation; Endangered and Endemic species, Hot spots of biodiversity.Threats to biodiversity: Habitat loss, poaching of wildlife, human-wildlife conflicts; Conservation of biodiversity: In situ and ex situ conservation; National biodiversity act.
MODULE IV	**ENVIRONMENTAL POLLUTION, POLLUTION CONTROL TECHNOLOGIES AND GLOBAL ENVIRONMENTAL PROBLEMS**
	Environmental pollution: Definition, causes and effects of air pollution, water pollution, soil pollution, noise pollution; Solid waste: Municipal solid waste management, composition and characteristics of e-waste and its management; Pollution control technologies: Waste water treatment methods, primary, secondary and tertiary; Concepts of bioremediation; Global environmental problems and global efforts: Global Warming, Climate change, Sea level rise, ozone depletion, ozone depleting substances, deforestation and desertification; International conventions / protocols: Earth summit, Kyoto protocol and Montreal protocol.
MODULE V	**ENVIRONMENTAL LEGISLATIONS AND SUSTAINABLE DEVELOPMENT**
	Environmental legislations: Environmental protection act, air act1981, water act, forest act. municipal solid waste management and handling rules, biomedical waste management and handling rules2016, hazardous waste management and handling rules, Environmental impact assessment(EIA); Towards sustainable future: Concept of sustainable development, population and its explosion, crazy consumerism, environmental education, urban sprawl, concept of green building.

TEXTBOOKS

1. Benny Joseph, "Environmental Studies", Tata Mc Graw Hill Publishing Co. Ltd, New Delhi, 1st Edition, 2006.
2. Erach Bharucha, "Textbook of Environmental Studies for Under Graduate Courses", Orient Black Swan, 2nd Edition, 2013.
3. Dr. P. D Sharma, "Ecology and Environment", Rastogi Publications, New Delhi, 12th Edition, 2015.

REFERENCE BOOKS:

1. Tyler Miller, Scott Spoolman, "Environmental Science", Cengage Learning, 14th Edition, 2012.
2. Anubha Kaushik, "Perspectives in Environmental Science", New Age International, New Delhi.4th Edition, 2006.
3. Gilbert M. Masters, Wendell P. Ela, "Introduction to Environmental Engineering and Science, Pearson, 3rd Edition, 2007

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)			
1	Explain the scope and importance of Environment and need for Public Awareness	CO 1	T1:1.1.3 R1:2.1
2	Identify scope and importance of ecosystem	CO1	T1:1.1.4 R1:2.7.1
3	Explain Structure and function of ecosystem	CO1	T1:1.1.6 R1:2.7.4
4	Relate the Food chain food web and pyramids	CO1	T1:1.7.2 R1:2.15
5	Realate the Flow of energy	CO1	T1:1.7.2 R1:2.16
6	Explain the Biogeochemical cycles.	CO1	T1:1.7.6 R1:2.17
7	Interpret the Biomagnifications.	CO1	T1:1.7.3 R1:2.19
8	Classify the Living and non living resources	CO 2	T1:2.1 R1:2.21
9	Explain the Water resources: use and over utilization of surface and ground water	CO 2	T1:2.2.2 R1:2.3
10	Explain the Floods and Drought	CO 2	T1:2.2.4 R1:4.1

11	Relate dams: befit and problems	CO 2	T1:2.3.1 R1:4.3
12	Explain the Mineral resources: use and exploitation of minerals	CO 2	T1:2.4 R1:4.8
13	Relate the Energy resources and introduction and applications	CO 3	T1:2.5.2 R1:4.6
14	Explain the Wind energy and its application	CO 3	T1:2.5.3 R1:4.6
15	Explain Land resources	CO 2	T1:2.4 R1:4.8
16	Identify renewable and non renewable resources	CO 3	T1:2.5.3 R1:4.6
17	Recall the Biodiversity and Biotic introduction and definition.	CO 4	T1:3.1 R1:4.5
18	Relate the Classification of biodiversity	CO 4	T1:3.2.2 R1:4.8
19	Explain the Values of biodiversity	CO 4	T1:3.3.1 R1:4.7
20	Identify India is mega diversity nation	CO 4	T1:3.4 R1:4.9
21	Recognize Hot spots of biodiversity	CO 4	T1: 3.4 R1:4.10
22	Explain the Threats to biodiversity	CO 4	T1: 3.5 R1:1.10
23	Explain the Man wild life conflict	CO 4	T1:3.5.2 R1:1.10
24	Relate the Conservation of Biodiversity	CO 4	T1:3.7 R1:1.16
25	Recall National biodiversity act	CO 4	T1: 3.9 R1:1.16
26	Recall the Environmental pollution : Introduction and classification	CO 5	T1: 4.1 R1:1.16
27	Explain the Air pollution: primary and secondary pollutants, effects and its control	CO 5	T1: 4.2 R1:1.11
28	Explain the Water pollution: types effects and control of water pollution	CO 5	T1:4.6 R1:5.2
29	Explain the Soil pollution: sources effects and control of soil pollution	CO 5	T1: 4.8 R1:5.2
30	Explain the Noise pollution: sources effects and control of noise pollution	CO 5	T1: 4.13 R1:5.10
31	Explain the Municipal waste management	CO 5	T1: 4.16 R1:5.2.3
32	Explain the solid waste management	CO 5	T1:4.16.3 R1:5.2.4
33	Identify the E-waste: characteristics and its management	CO 5	T1: 5.5 R1:5.4
34	Explain the Global environmental problems: climate change and impact on human	CO 5	T1: 5.6 R1:5.5

35	Recognize the Ozone depletion and consequences	CO 5	T1: 5.10 R1:5.6
36	Summarize the International protocols	CO 5	T1: 4.1 R1:1.16
37	Relate the Environmental protection act.	CO 6	T1:7.3
38	Relate the air act, water act	CO 6	T1:7.3
39	Relate forest act, wild life act	CO 6	T1:7.3
40	Relate the Hazardous waste management and handling rules 2016	CO 6	T1:7.10
41	Illustrate the EIA structure and concept of sustainable development	CO 6	T1: 8.1
42	Identify towards sustainable features: concepts of sustainable development	CO 6	T1: 8.2
43	Relate the Consequences of population and its explosion	CO 6	T2: 8.2.3 T3:2
44	Explain the Crazy consumerism urban sprawl	CO 6	T2:8.2.3, T3:7
45	Explain the Environmental education	CO 6	T2:8.4, T3:7
46	Explain the Environmental ethics and concepts of green buildings	CO 6	T2:8.12, T3:15,21
PROBLEM SOLVING			
1	Food chain and pyramids	CO 1	T1:3.3.1; R3:3.2
2	Probelms on utilization of water	CO 1	T2:16.5; R3:8.10
3	Biodiversity	CO 2	T2:16.5; R3:8.10
4	kyto protocol	CO 3	T1:3.3.1; R3:3.2
5	Deforestation	CO 3	T2:16.5; R3:8.10
6	population	CO 4	T2:16.5; R3:8.10
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Environment and Ecosystems	CO 1	T2:16.5; R3:8.10
2	Natural Resources	CO 2	T1:3.3.1; R3:3.2
3	Biodiversity and Biotic Resouces	CO 3	T2:16.5; R3:8.10
4	Enivironment pollution	CO 4	T2:16.5; R3:8.10
5	Environmental Legistration and sustainable development	CO 6	T2:16.5; R3:8.10

DISCUSSION OF QUESTION BANK			
1	Environment and Ecosystems	CO 1	T2:16.5; R3:8.10
2	Natural Resources	CO 2	T1:3.3.1; R3:3.2
3	Biodiversity and Biotic Resouces	CO 3	T2:16.5; R3:8.10
4	Enivironment pollution	CO 4	T2:16.5; R3:8.10
5	Environmental Legistration and sustainable development	CO 6	T2:16.5; R3:8.10

Signature of Course Coordinator **HOD,AERO**

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

ELECTRICAL AND ELECTRONICSENGINEERING
COURSE DESCRIPTION

Course Title	**COMPUTATIONAL MATHEMATICS LABORATORY**				
Course Code	AHS102				
Program	B.Tech				
Semester	II	ME			
Course Type	Foundation				
Regulation	IARE- R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Ms. B Praveena, Assistant Professor				

I COURSE OVERVIEW:

II. The aim of this course is to know about the basic principles of Engineering Mathematics and itsapplication in MATLAB by means of software. Nowadays the principles of MATLAB find widerange of applications in many situations such as signal processing and communications, imageandvideoprocessing,controlsystems,testandmeasurement,computationalfinance,andcomputational biology. Using MATLAB, one can analyze data, develop algorithms, and createmodelsandapplications.

II COURSE PRE-REQUISITES:

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

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Computational Mathematics 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	DemonstratethebasicprinciplesofMATLAB.
II	Analyze the applications of Algebraand Calculus using MATLAB software.
III	Estimate the roots of Algebraic and Transcendental equations..
IV	Evaluate the characteristics of given curves bymeans of plottingagraph.

VII COURSE OUTCOMES:

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

CO 1	**Solve** the algebraic and transcendental equations with in given range rangeusing MAT LAB programs. .	Apply

CO 2	**Utilize** MAT LAB programs for verifying properties of limits,derivatives of a function.	Apply
CO 3	**Interpret** rank,eigen values and vectors with matrix transformations.	Understand
CO 4	**Utilize** MAT LAB programs for solving differential equations and multiple integrals.	Apply
CO 5	**Make use of** of MAT LAB programs for interpolating values of differential equations numerically.	Apply
CO 6	**Use** MAT LAB programs for vector operations on vector field.	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:** Problem analysis: Identify, formulate, review research literature, and analyze complexengineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	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.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	ProfessionalSkills:To produce engineering professiona lcapable of synthesizing and analyzing mechanical systems including allied engineering streams	1	Presentation on real-world problems

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	Identify (given **problem statement**)MAT LAB commands for synthesizing and analyzing the given data (provided **information and data**) by principles of Mathematics.	4
	PO 4	Apply (given **problem statement**)MAT LAB commands for analyzing the given data **information and data**) by using various algebraic functions numerically.	2
	PSO 1	Apply (**knowledge**) properties, various types and patterns of fluid flow configurations (apply) for solving design problems by applying the **in various engineering streams following mathematical rules and conditons.**	1
CO 2	PO 1	Identify (understanding) the appropriate MAT LAB programs for verifying limitsand derivatives of the givenfunctions and Understand the major role of these functions which exists as solutions **for integrals and differential equations of elementary functions by applying the principles of mathematics.**	3

	PO 2	Identify (given **problem statement**) the given problem and formulate MAT LAB program for solving and make use of mathematical method **information**to facilitate physical interpretation of the results obtained.	4
	PO 4	Apply (given **problem statement**) the given problem and formulate MAT LAB program for solving and make use of mathematical method MAT LABcommands for synthesizing and analyzing the given data **information**in various engineering streams following mathematical rules and conditons.	2
	PSO 1	Apply (knowledge) MAT LAB commands for synthesizing and analyzing the given data **in various engineering streams following mathematical rules and conditons.**	1
CO 3	PO 1	Interpret (**knowledge**) the rank and inverse of real and complex matrices using MAT LAB programs.	3
	PO 2	Apply **problem statement** MAT LAB program for decomposing the given matrix for (**complex**) solving complex engineering problems following principles ofmathematics. **results**.	4
	PO4	Apply (knowledge) MAT LAB programfor finding Eigen values and Eigen vectors along **with basic principles of mathematics to develop the solution.**	2
	PSO 1	Apply (knowledge)MAT LAB commands for synthesizing and analyzing the given data **in various engineering streams following mathematical rules and conditons.**	1
CO 4	PO 1	Identify (knowledge) appropriate MAT LAB programsforfinding length of the curves and area of the surfacefor with respect to **the fundamental operations of arithmetic(knowledge) for majority of functions by principlesofMathematics.**	3
	PO 2	Interpret **problem statement and formulate** the suitable MAT LAB program for solving double and triple integral in the given region.	2
	PSO 1	Apply (knowledge) MAT LAB commands for synthesizing and analyzing the given data in various engineering streams	1
CO 5	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals**the knowledge of MAT LAB programs. toSolve the algebraic and transcendental equations numerically with in given range .	3
	PSO 1	Apply **problem statement** MAT LAB commands for synthesizing and analyzing the given data in various engineering streams following mathematical rules and conditons.	1

CO 6	PO 1	Develop **Mathematics and Engineering fundamentals** the formulation of differential calculus of complex engineering problems which transforms vector functions, gradient, Divergence and curl using principle of mathematics to the realworld engineering problems by using MAT LAB programs.	3
	PO 2	Apply **principles of Sciences and Engineering fundamentals** the formulation of integral transformations to complex engineering problems related to surface and volume, line and surface of different geometrical models using principle of mathematics in the domain of engineering to reach conclusions by interpretation of results.	2
	PSO 1	Apply **understand the innovative and dynamic challenges** MAT LAB commands for synthesizing and analyzing the given data in various engineering streams following mathematical rules and conditons.	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 1
CO 1	3	2	1	1
CO 2	3	2	1	1
CO 3	3	2	1	1
CO 4	3	1	-	1
CO 5	3	-	-	1
CO 6	3	1	-	1

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	**BASIC FEATURES**
	To Know the history and features of MATLAB, To Know the loca lenvironment of MATLAB
WEEK II	**ALGEBRA**
	Solving basic algebraic equations, Solving system of equations, Two dimensional plots.
WEEK III	**CALCULUS**
	Calculating limits, Solving differential equations, Finding definite integral.
WEEK IV	**MATRICES**
	Addition,subtraction and multiplication of matrices, Transpose of a matrix, Inverse of a matrix.
WEEK V	**SYSTEMOF LINEAREQUATIONS**
	Rank of a matrix, Gauss Jordan method, LU decomposition method.
WEEK VI	**LINEARTRANSFORMATION**
	Characteristic equation, Eigen values, Eigen vectors.
WEEK VII	**DIFFERENTIATIONANDINTEGRATION**
	a. Higher order differential equations, Double integrals, Triple integrals.
WEEK VIII	**INTERPOLATION AND CURVEFITTING**
	Lagrange polynomial, Straight linefit, Polynomial curve fit.
WEEK IX	**ROOT FINDING TECHNIQUES**
	Bisection method, Regulafalsemethod, NewtonRaphsonmethod.
WEEK X	**NUMERICAL DIFFERENTION AND INTEGRATION**
	Trapezoidal, Simpson‘smethod, Eulermethod, RungeKuttamethod.
WEEK XI	**3D PLOTTING**
	Line plotting, Surfaceplotting Volumeplotting.
WEEK XII	**VECTORCALCULUS**
	Gradient, Divergent, Curl.

TEXTBOOKS

1. 1. Dean G.Duffy, Advanced Engineering Mathematics with MATLAB, CRC Press,Taylorand Francis Group,6thEdition,NewDelhi,2015.

REFERENCE BOOKS:

1. 1.Cleve Moler,Numerical Computing with MATLAB,SIAM,Philadelphia,2ndEdition,2008.

XV COURSE PLAN:

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

S.No	Topics to be covered	CO’s	Reference
1	Understanding thebasic featuresof MATLAB.	CO 1	T1:1.1 R1:2.21

2	Determination of roots of agiven polynomial.	CO 1	T1:15.1 R1:2.25
3	Verification of basic properties of limits.	CO 2	T1:2.1 R1:2.21
4	Determination ofrank,inverse,transpose and obtaining the solution to linear system of equationsofamatrix.	CO 3	T1-15.6 R1:2.32
5	Interpret the Eigen values and Eigenvectors of a matrix.	CO 3	T1:15.5 R1:2
6	Determination of derivatives and integration toa Given function.	CO 4	T1:2.1 R1:2.8
7	Determination of bestfit curve to the given data	CO 6	T1:3.0 R1:2.9
8	Calculation of areaenclosed bounded bya region.	CO 4	T1:14.5 R1:5.1
9	Solving the higher order differential equations.	CO 4	T1:3.1 R1:5.21
10	Plotting agiven surface bounded in a region.	CO 4	T1:14.3-14.8 R1:5.1
11	Determination of gradient,divergence and cur of avector. .	CO 5	T1:14.2 R1:2.2
12	Determination of roots to algebraic and transcendental equations by bisection method, Method of false position and Newton-Raphson method	CO 6	T1:2.2 R1:2.25

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Algebraic equations:** Apply MAT LAB programs to algebraic equations
2	**Differentiation:** Apply MAT LAB programs differential equations and matrices .
3	**Matrices:** Apply MAT LAB programs to eigen values and eigen vectors.
4	**Numerical methods** Apply MAT LAB programs to numerical methods
5	**Vector calculus:** Apply MAT LAB programs to vector calculus

Signature of Course Coordinator **HOD,ME**
Ms. B Praveena, Assistant Professor

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

COURSE DESCRIPTION

Department	**COMPUTER SCEINCE AND ENGINEERING**				
Course Title	**COMPUTATIONAL MATHEMATICS AND INTEGRAL CALCULUS**				
Course Code	AHS003				
Program	B. Tech				
Semester	I				
Course Type	Foundation				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Ms. V Subbalaxmi, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
10+2	-	I	Basic Principles of complex functions

II COURSE OVERVIEW:

The course focuses on more advanced Engineering Mathematics topics which provide with the relevant mathematical tools required in the analysis of problems in engineering and scientific professions. The course includes Types of Interpolation, Curve fitting, Numerical solutions of Ordinary Differential Equations, Multiple Integrals, Vector Calculus and Special functions. The mathematical skills derived from this course form a necessary base to analytical and design concepts encountered in the program.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Computational Mathematics And Integral Calculus	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
36 %	Understand
64 %	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	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 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:

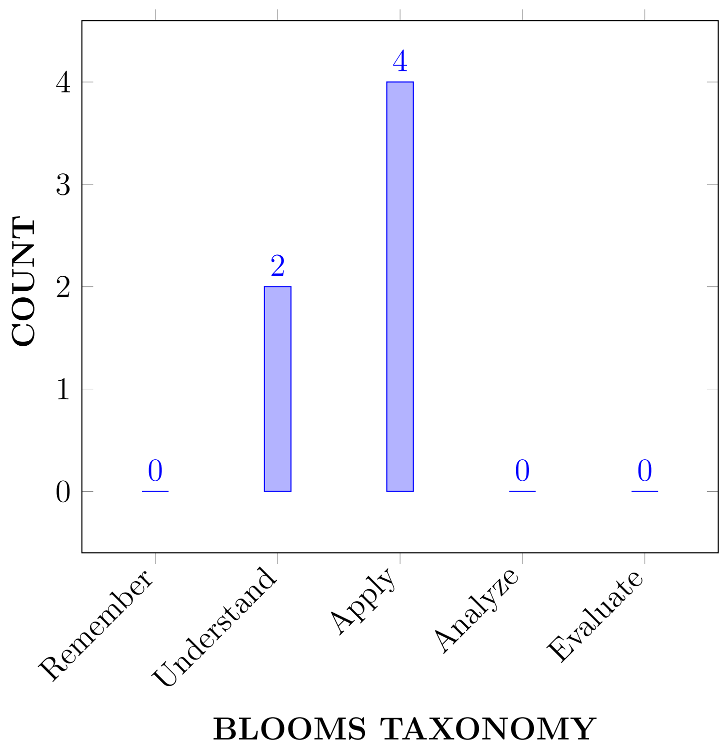
I	Enrich the knowledge of solving algebraic, transcendental and differential equation by numerical methods.
II	Apply multiple integration to evaluate mass, area and volume of the plane
III	Apply gradient, divergence and curl to evaluate the integration over a vector field
IV	Apply the Bessel's equation to solve them under special conditions with the help of series solutions.

VII COURSE OUTCOMES:

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

CO 1	**Apply** numerical methods for solving algebric ,transcendental equations and interpolating the data	Apply
CO 2	**Make use of** least squares methods for fitting straight lines,the second degree, exponential and power curves .	Apply
CO 3	**Utilize** numerical methods for solving linear diffrential equations with initial conditions	Apply
CO 4	**Identify** the limits of definite integrals for calculating the area of solids.	Understand
CO 5	**Extend** vector operations and theorems for finding line,surface and volume integrals .	Apply
CO 6	**Determine** characterstics of special functions for solving proper and improper integrals	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Apply** the **basic properties** of numerical methods for solving algebric ,transcendental equations and interpolating the data algebra and applicability in solving (complex) majority of functions by applying **Mathematical principles**.	2
	PO 2	**Apply** the of numerical methods as a **formulation** of mathematical function in **complex engineering problems** which transformations a algibric and transcendental equations using **principle of mathematics** to attain conclusion by the **interpretation of results** .	4
CO 2	PO 1	**Make use of** the **basic properties** of least squares methods for solving fitting straight lines,the second degree, exponential and power curves by using **Mathematical principle** .	2
CO3	PO 1	**Utilize** the **basic properties** of numerical methods for solving linear diffrential equations with initial conditions by applying **Mathematical principles**.	2
	PO 2	**Apply** the of numerical methods as a **formulation** of mathematical function in **complex engineering problems** linear diffrential equations with initial conditions using **principle of mathematics** to attain conclusion by the **interpretation of results** .	4
CO4	PO 1	**Identify** the **basic properties** of the limits of definite integrals for calculating the area of solids by applying **Mathematical principles**.	2
	PO 2	**Identify** the integrals for calculating the area as a **formulation** of mathematical function in **complex engineering problems** which multiple integral using **principle of mathematics** to attain conclusion by the **interpretation of results**	4
CO5	PO1	**Extend** the vector operations and theorems for finding line,surface and volume integrals by using **priniciples of Mathematics** .	2
CO6	PO1	**Identify** the **Formulation** of improper integrals and their classification for applicability in solving special functions by applying the **principles of mathematics**.	2
	PO 2	**Solve** the of improper integrals as a **formulation** of mathematical function in **complex engineering problems** which transformatimations of equations using **principle of mathematics** to attain conclusion by the **interpretation of results** .	4

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	40	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.7	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.7	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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	2	-	-	-	-	-	-	-	-	-	-	-	-	
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	8	-	-	-	-	-	-	-	-	-	-	-	-	-
AVERAGE	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester OBE Feedback	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**ROOT FINDING TECHNIQUES AND INTERPOLATION**
	Solving algebraic and transcendental equations by bisection method, method of false position Newton-Raphson method; Interpolation: Finite differences, forward differences, backward differences and central differences; Symbolic relations; Newton's forward interpolation, Newton's backward interpolation; Gauss forward central difference formula, Gauss backward central difference formula; Interpolation of unequal intervals: Lagrange's interpolation, Newton's divided difference interpolation.
MODULE II	**CURVE FITTING AND NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS**
	Fitting a straight line; Second degree curves; Exponential curve, power curve by method of least squares. Taylor's series method; Step by step methods: Euler's, modified Euler's and Runge-Kutta method.
MODULE III	**MULTIPLE INTEGRALS**
	Double and triple integrals; Change of order of integration. Change of variables: Polar, cylindrical and spherical; Finding the area of a region using double integration and volume of a region using triple integration.
MODULE IV	**VECTOR CALCULUS**
	Scalar and vector point functions; Gradient, divergence, curl and their related properties; Solenoidal and irrotational vector point functions; Scalar potential function; Laplacian operator; Line integral, surface integral and volume integral; Vector integral theorems: Green's theorem in a plane, Stoke's theorem and Gauss divergence theorem without proofs.
MODULE V	**SPECIAL FUNCTIONS**
	Gamma function, properties of gamma function; Ordinary point and regular singular point of differential equations; Series solutions to differential equations around zero, Frobenius method about zero; Bessel's differential equation: Bessel functions properties, recurrence relations, orthogonality, generating function, trigonometric expansions involving Bessel functions.

TEXTBOOKS

1. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons Publishers, 10th Edition,2010
2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 43rd Edition,2015

REFERENCE BOOKS:

1. T.K.V Iyengar, B.Krishna Gandhi, "Engineering Mathematics - III", S. Chand & Co., 12th Edition, 2015..
2. Churchill, R.V. and Brown, J.W, "Complex Variables and Applications", Tata Mc Graw-Hill, 8th Edition, 2012.

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

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Introduction to outcome based education		
CONTENT DELIVERY (THEORY)			
2	Define Algebraic and Transcendental equations	CO 1	T1:12.1,R1:4.2
3	Apply Bisection method to find the root	CO 1	T1:12.3, R1:4.4
4	Apply False Position method to find the root	CO 1	T1:12.3, R1:4.6
5	Apply Newton-Raphson method to find roots	CO 1	T1:12.3, R1:4.7
6	Define what interpolation is	CO 1	T1:12.4, R1:4.13
7	Explain the relation between symbols	CO 1	T1:12.4, R1:4.15
8	Solve the problems by Newton's forward method	CO 1	T1:12.4, R1:4.20
9	Solve the problems by Newton's backward method	CO 1	T1:22.9 R1:5.8
10	Solve the problems by Gauss forward method	CO 1	T1:13.1, R1:5.3
11	Solve the problems by Gauss backward method	CO 1	T1:13.2, R1:5.5
12	Solve the problems by lagrange's and Newtons dividend difference	CO 1	T1:13.3, R1:5.9
13	Define Algebraic and Transcendental equations	CO 1	T1:13.4, R1:5.10

14	Apply Bisection method to find the root	CO 1	T1:14.1, R1:6.1
15	Solve the problems by lagrange's and Newtons dividend difference	CO 1	T1:14.2 , R1:6.1
16	Solve a straight line	CO 2	T1:14.4, R1:6.2
17	Solve a second degree parabola	CO 2	T1:15.2 , R1:6.6
18	Solve an exponential curve	CO 2	T1:15.1, R1:7.4,
19	Solve the ODE by Taylor's series method	CO 3	T1:15.1, R1:6.5
20	Solve the ODE by Euler's Method- Euler's modified method	CO 3	T1:15.3, R1:7.9
21	Explain the ODE by Taylor's series method	CO 3	T2: 7.14, R1:1.6
22	Explain the ODE Euler's modified method	CO 3	T2: 7.15, R1:1.63
23	Solve the ODE by Runge-Kutta Methods	CO 3	T2: 7.15, R1:1.65
24	Calculate double and triple integrations	CO 4	T2: 16.5, R1:7.32
25	Use the Change of order for multiple integrals	CO 4	T2: 16.6, R1:7.36
26	Use the Change of variables in multiple integrals	CO 4	T2: 16.7, R1:7.36
27	Apply double integration for finding the area	CO 4	T2: 16.8, R1:7.41
28	Apply triple integration for finding the volume	CO 4	T2: 16.9, R1:7.42
29	Define vector calculus and vector fields and their properties	CO 5	T2: 16.9, R1:7.42
30	Determine Gradient, divergent and curl of vector fields	CO 5	T2: 7.14, R1:1.6
31	Calculate line integral along smooth path and find work done	CO 5	T2: 7.15, R1:1.65
32	Calculate the surface area of field	CO 5	T2: 7.15, R1:1.65
33	Calculate volume of field	CO 5	T2: 7.15, R1:1.65
34	Use Green's theorem to evaluate line integrals along simple closed contours on the plane	CO 5	T2: 16.5, R1:7.32
35	Use Stokes' theorem to give a physical interpretation of the curl of a vector field	CO 5	T2: 16.6, R1:7.36
36	Use the divergence theorem to give a physical interpretation of the divergence of a vector field	CO 5	T2: 16.7, R1:7.36
37	Apply gamma function for improper integrals	CO 6	T2: 16.7, R1:7.36

38	Motivation for series solution Ordinary and regular point of a differential equation	CO 6	T2: 16.8, R1:7.41
39	Transformation of non-zero singular point to zero singular point series solutions of differential equations around zero	CO 6	T2: 16.8, R1:7.41
40	Frobenius Method about zero	CO 6	T2: 16.9, R1:7.42
41	Explain the Bessel functions	CO 6	T2: 16.5, R1:7.32
42	Determine the solution of ordinary differential equations in series form	CO 6	T1:12.3, R1:4.4
43	Apply the Frobenius method to obtain a series solution for the given linear ODE	CO 6	T1:12.3, R1:4.7
44	Demonstrate Bessel's Differential equation	CO 6	T1:12.4, R1:4.13
PROBLEM SOLVING/ CASE STUDIES			
45	Solving problems on bisection,false position method	CO 1	T1:17.1-17.2 R1:16.1-16.2
46	Solving problems on Newton Raphson method	CO 1	T1:17.5-17.6 R1:16.3.1
47	Solving problems on interpolation methods	CO 1	T1:17.1-17.2 R1:16.1-16.2
48	Solving problems on straightlines ,second degree .exponential curves least squares method	CO 2	T1:17.5-17.6 R1:16.3.1
49	Solving problems onTaylor's series method	CO 3	T1:17.1-17.2 R1:16.1-16.2
50	Solving problems onStep by step methods: Euler's, modified Euler's	CO 3	T1:23.10 R1:8.1
51	Solving problems on Runge-Kutta method	CO 3	T1:23.1 R1:9.2
52	Solving problems on Double and triple integrals	CO 4	T1:23.1 R1:9.4
53	Solving problems on Vector integral theorems	CO 5	T1:23.1 R1:9.9
54	Solving problems on properties of gamma function	CO 6	T1:23.10 R1:8.1
55	Solving problems on properties of Bessel function, Recurrence relations of Bessel function, Generating function and orthogonality of Bessel function	CO 6	T1:17.1-17.2 R1:16.1-16.2

56	Solving problems onTrigonometric expansions involving Bessel function.	CO 6	T1:17.1-17.2 R1:16.1-16.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Definitions and terminology of Module I on Root finding techniques and interpolation	CO 1	T1:23.10 R1:6.8
58	Definitions and terminology of Module II on Curve fitting and numerical solution of ordinary differential equations	CO 2, CO 3	T1:23.10 R1:7.5
59	Definitions and terminology of Module III on Multiple integrals	CO 4	T1:23.10 R1:8.1
60	Definitions and terminology of Module IV on Vector calculus	CO 6	T2:27.12 R1:11.10
61	Definitions and terminology of Module V on Special functions	CO 6	T1:17.1-17.2 R1:16.1-16.2
DISCUSSION OF QUESTION BANK			
62	Discussion of Question Bank of Module I on Root Finding Techniques and Interpolation	CO 1	T1:23.10 R1:8.1
63	Discussion of Question Bank of Module II on Curve Fitting and Numerical Solution of Ordinary Differential Equations	CO 2, CO 3	T1:23.10 R1:6.8
64	Discussion of Question Bank of Module III on Multiple Integrals	CO 4	T1:23.10 R1:7.5
65	Discussion of Question Bank of Module IV on Vector calculus	CO 5	T2:27.12 R1:11.10
66	Discussion of Question Bank of Module V on Special Functions	CO 6	T1:17.1-17.2 R1:16.1-16.2

Course Coordinator: **HOD, CSE**
Ms V Subbalaxmi , Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

Aeronautical Engineering

COURSE DESCRIPTION

Course Title	**COMPUTER PROGRAMMING**				
Course Code	ACS001				
Program	B.Tech				
Semester	I	AE|ME			
	II	CSE|IT|ECE |EEE			
Course Type	Foundationl				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	4	2
Course Coordinator	Mrs.K.Laxminarayanamma,Assistant Professor				
Course Faculty	Dr K Srinivasa Reddy, Professor, IT Dept				

I COURSE OVERVIEW:

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

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	ACSS001	I	Basic Programming Concepts	-

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
16.66%	Remember
25 %	Understand
58.33 %	Apply
0 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of 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 / Alternative Assessment Tool (AAT):

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are be answered by choosing the correct answer from a given set of choices (commonly four). Marks shall be awarded considering the average of two quizzes for every course. The AAT may include seminars, assignments, term paper, open ended experiments, five minutes video and MOOCs.

VI COURSE OBJECTIVES:

The students will try to learn:

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

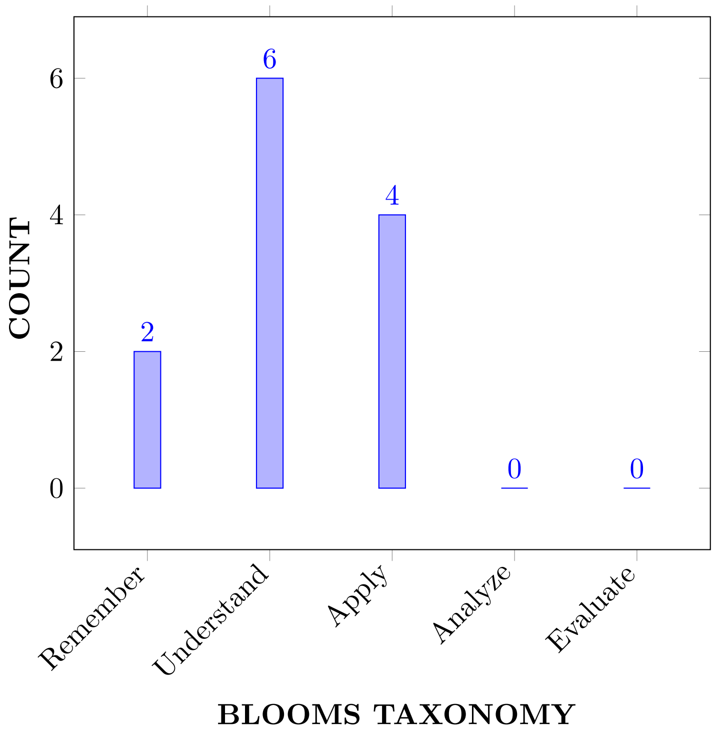
VII COURSE OUTCOMES:

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

CO 1	**Illustrate** problem solving steps in terms of algorithms, pseudocode, flowcharts and programs with basic data types and operations for Mathematical and Engineering problems.	Understand

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

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	Assignments
PO 2	**Problem 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	Assignments
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	Seminars, Viva

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	5 minutes video

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	Projects
PSO 2	Focus on formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	3	Lectures, Assign-ments
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	Lectures, Assign-ments

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	Understand the basics of computers; **Fundamentals** of Computer System and memory organization, and **identify** the components of the computer system.	2
CO 2	PO 1	Developing algorithms and draw flowcharts for solving **mathematical** and **engineering problems** related to **areas of computer science.**	2
	PO 2	Understand the various symbols to **drawa** flowchart, **identify** the appropriate symbols to solve a problem, then **formulate** the solution, and **interpret** the result for the **improvement** of the solution.	5

	PO3	**Recognize** an appropriate control structure to **design** and **develop** a solution for a **real-time** scenario, and communicating effectively with engineering community.	3
	PO5	Describe the operators, their precedence, and associativity while evaluating expressions in **software program**.	1
	PSO1	Understand the features of procedural programming for **designing** and **analysing** computer programs for **problem-solving**.	3
CO 3	PO 1	Apply the knowledge of **mathematics, C language fundamentals** to design, develop, and debug programs to solve **engineering** problems	3
	PO 2	Understand the **problem statement**, identify the **data requirements, design**, and **develop** a system for an engineering problem, **validate** and **interpret** the results.	6
	PSO 1	**Understand** automatic type conversion rules to **determine** the magnitude and precision of a mixed datatype expression in the areas of **software development.**	4
CO 4	PO 1	Describe the **fundamental programming** constructs, and articulate how they are used to **develop a program** with a desired runtime execution flow.	3
	PO 2	**Identify** the appropriate datatypes to **formulate, develop** and **analyze** the solution to achieve **engineering** objectives.	6
	PO 3	Recognize right **data representation** formats based on the **requirements** for **developing programs** in **real-time scenarios** by **managing** the **design process**, and communicating effectively with **engineering** community.	7
	PO 5	Describe the operators, their precedence, and associativity while evaluating expressions in **software program.**	1
CO 5	PO 1	Understand branching statements, loop statements, and apply the fundamentals of **mathematics, science** and **engineering.**	2
	PO 2	Understand the **problem statement, control** the flow of data, **design** the solution and **analyse** the same to **validate** the results in a program to solve complex engineering problems.	5
	PO 3	**Recognize** an appropriate control structure to **design** and **develop** a solution for a **real-time** scenario, and **communicating** effectively with engineering community.	5
CO 6	PO 1	Make use of **engineering techniques** to design and develop solutions for real-time **computational problems.**	2
	PSO 1	**Identify** tasks in which the numerical techniques are **applicable, develop** programs, and hence use computers effectively to solve**real-time applications.**	6

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

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

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

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	67	-	-	27	100	-	-	-	-	40	-	25	25	-	50
CO 2	67	50	30	-	100	-	-	-	-	40	-	37	50	-	-
CO 3	100	60	-	-	100	-	-	-	-	20	-	37	67	-	50
CO 4	100	60	70	27	100	-	-	-	-	20	-	37	25	-	50
CO 5	67	50	50	-	100	-	-	-	-	40	-	37	25	-	-
CO 6	67	-	-	-	100	-	-	-	-	40	-	37	34	-	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	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	1	3	-	-	-	-	2	-	1	1	-	2
CO 2	3	2	1	-	3	-	-	-	-	2	-	1	2	-	-
CO 3	3	2	-	-	3	-	-	-	-	1	-	1	3	-	2
CO 4	3	2	3	1	3	-	-	-	-	1	-	1	1	-	2
CO 5	3	2	2	-	3	-	-	-	-	2	-	1	1	-	-
CO 6	3	-	-	-	3	-	-	-	-	2	-	1	1	-	2
TOTAL	18	8	6	4	18	-	-	-	-	10	-	6	9	-	8
AVERAGE	3	2	2	1	3	-	-	-	-	1.67	-	1	1.5	-	2

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1,PO 2, PO 3, PO 4	SEE Exams	PO 1, PO 2, PO 3, PO 4	Seminars	PO 3
Laboratory Practices	PO 1	Student Viva	PO3	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments	PO 2	-	-	-	-

XVII ASSESSMENT METHODOLOGY INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**INTRODUCTION**
	Introduction to computers: Computer systems, computing environments, computer languages, creating and running programs, algorithms, flowcharts; Introduction to C language: History of C, basic structure of C programs, process of compiling and running a C program, C tokens, keywords, identifiers, constants, strings, special symbols, variables, data types; Operators and expressions: Operators, arithmetic, relational and logical, assignment operators, increment and decrement operators, bitwise and conditional operators, special operators, operator precedence and associativity, evaluation of expressions, type conversions in expressions, formatted input and output.
MODULE II	**CONTROL STRUCTRES**
	Control structures: Decision statements; if and switch statement; Loop control statements: while, for and do while loops, jump statements, break, continue, goto statements; Arrays: Concepts, one dimensional arrays, declaration and initialization of one dimensional arrays, two dimensional arrays, initialization and accessing, multi dimensional arrays; Strings concepts: String handling functions, array of strings.
MODULE III	**ARRAYS AND FUNCTIONS**
	Functions: Need for user defined functions, function declaration, function prototype, category of functions, inter function communication, function calls, parameter passing mechanisms, recursion, passing arrays to functions, passing strings to functions, storage classes, preprocessor directives. Pointers: Pointer basics, pointer arithmetic, pointers to pointers, generic pointers, array of pointers, pointers and arrays, pointers as functions arguments, functions returning pointers.
MODULE IV	**POINTERS AND STRUCTURES**
	Structures and unions: Structure definition, initialization, accessing structures, nested structures, arrays of structures, structures and functions, passing structures through pointers, self referential structures, unions, bit fields, typedef, enumerations; Dynamic memory allocation: Basic concepts, library functions.
MODULE V	**FILE HANDLING AND APPLICATIONS IN C**

	Files: Streams, basic file operations, file types, file opening modes, file input and output functions, file status functions, file positioning functions, command line arguments.

TEXT BOOKS

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

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

REFERENCE BOOKS:

1. W. Kernighan Brian, Dennis M. Ritchie —The C Programming Language, PHI Learning, Second Edition, 1988.

2. YashavantKanetkar —Exploring C, BPB Publishers, Second Edition, 2003..

3. Schildt Herbert —C: The Complete Reference, Tata McGraw Hill Education, Fourth Edition, 2014.

Web References:

1. https://www.bfoit.org/itp/Programming.html

2. https://www.khanacademy.org/computing/computer-programming

3. https://www.edx.org/course/programming-basics-iitbombayx-cs101-1x-0

4. https://www.edx.org/course/introduction-computer-science-harvardx-cs50x

E-Text Books:

1. http://www.freebookcentre.net/Language/Free-C-Programming-Books-Download.htm

2. http://www.imada.sdu.dk/ svalle/courses/dm14-2005/mirror/c/

3. http://www.enggnotebook.weebly.com/uploads/2/2/7/1/22718186/ge6151-notes.pdf

MOOC Course:

1. https://www.alison.com/courses/Introduction-to-Programming-in-c

2. http://www.ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-s096-effective-programming-in-c- and-c-january-iap-2014/index.htm

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**
1-2	Introduction to Computers: computer systems, computing environments, Computer languages, creating and running programs	CO 1	T2: 1.1-1.2
3-4	Algorithms, flowcharts; Introduction to C language: Computer languages, History of C, basic structure of C programs, process of compiling and running a C program	CO 2	T2: 2.1-2.2
5-6	C tokens, keywords, identifiers, constants, strings	CO 2	T2: 1.4-1.5
7-8	Special symbols, variables, data types	CO 3	T2:2.1-2.2

9-10	Operators and expressions	CO 3	T2: 2.3-2.6,7
11-12	Simple if, if-else, else if ladder, Nested if and Case Statement-switch statement	CO 3	T2:3.1-3.5
13-14	While, for and do while loops	CO 5	T2: 5.2-5.3
15–16	Jump statements, break, continue, goto statements	CO 7	T2: 6.1-6.6
17–18	Concepts, one dimensional arrays, declaration and initialization of one-dimensional arrays	CO 9 4	T2: 6.7
19–20	Two dimensional arrays, initialization and accessing	CO 13	T2: 8.1-8.3
21-22	Multi-dimensional arrays; Strings: Arrays of characters	CO 13	T2: 11.1-11.5
23-24	Variable length character strings, inputting character strings, character library functions, string handling functions	CO 15	T2: 4.1-4.5
25	Need for user defined functions, function declaration, function prototype	CO 15	T1:7 T2: 6.9
26	Category of functions, inter function communication, function calls	CO 11	T1:10T2:10.1-10.2
27	Parameter passing mechanisms, recursion, passing arrays to functions, passing strings to functions,	CO 16	T2:10.3-10.5
28	Storage classes, preprocessor directives	CO 16	T1:8.9
29	Structure definition, initialization, accessing structures, nested structures	CO 16	T2: 12.3-12.4
30	Unions, C programming examples, BitFields, typedef, enumerations	CO 16	T2:12.4
31-32	Arrays of structures, structures and functions, passing structures through pointers, self-referential structures	CO 17	T2:2.1-2.2
33-34	Unions, bit fields, typedef, enumerations	CO 17	T2: 2.3-2.6,7
35–36	Pointer basics, pointer arithmetic, pointers to pointers, generic pointers, array of pointers, pointers and arrays	CO 19	T2: 5.2-5.3
37	Pointers as functions arguments, functions returning pointers	CO 19	T2: 5.2-5.3
38	Dynamic memory allocation: Basic concepts, library functions	CO 20	T2: 6.1-6.6
39	Streams, basic file operations, file types, file opening modes, input and output operations with files	CO 20	T2:10.4
40-41	Special functions for working with files, file positioning functions	CO 21	R3:12.1-12.3
42	Command line arguments. Searching	CO 22	R3:12.4
43	Sorting algorithms bubble, insertion, selection	CO 23	T2:11.4 R7:13.1
44-45	Algorithm complexity through example programs	CO 23	T2:11.4 R7:13.1

	Algorithms and Flowcharts	CO 1	T2:2.1-2.2, R4:1.4
	Operators, Precedence and Associativity of Operators, Expression Evaluation	T2:2.3-2.6	
	Simple if, if-else, else if ladder, Nested if and Case Statement-switch statement	CO 2	T2:3.1-3.5
	While, for and do while loops, Jump statements, break, continue, goto statements	CO 3	T2:5.2-5.3,T2:6.1-6.6
	One dimensional arrays	CO 3	T2: 8.1-8.2, R4:15.1
	Strings and its operations	CO 3	T2: 8.3, R4: 15.1
	User defined Functions, Parameter passing mechanisms, passing arrays to functions, passing strings to functions,	CO 4	T1:10, T2:10.1 10.2, T2:10.3-10.4, R4:8.3-8.5
	Recursion	CO 4	T2:10.5
	Pointer basics, pointer arithmetic, pointers to pointers, generic pointers, array of pointers, pointers and arrays Pointers as functions arguments, functions returning pointers, Dynamic Memory Allocation	CO 4	T2:3.1,R4:11.1
	Storage classes, pre-processor directives	CO 5	T2:6.1-6.6
	Structure definition, initialization, accessing structures	CO 5	T1:8.9,T2:2.3-2.5
	Unions, bit fields, typedef, enumerations, command line arguments	CO 5	T2: 12.3-12.4,R4:13.4
	File Handling	CO 6	T2:10.4,R4:14.1-14.4
	Introduction	CO 1,2	T2:1.1-1.5,T2:2.1-2.6
	Control Structures	CO 3	T2: 3.1 –3.5, T2:5.2 – 5.3
	Arrays and Functions	CO 4	T2: 8.1 –8.3, R4:15.1
	Pointer and Structures	CO 5	T2: 12.3–12.4,R4: 13.2–13.4,T1: 8.9
	File Handling and Applications In C	CO 6	T2: 10.4,T2: 14.1– 14.4

	Module I	CO 1,2	T2:1.1-1.5,T2:2.1-2.6
	Module II	CO 3	T2: 3.1 –3.5, T2:5.2 – 5.3
	Module III	CO 4	T2: 8.1 –8.3, R4:15.1
	Module IV	CO 5	T2: 12.3–12.4,R4: 13.2–13.4,T1: 8.9
	Module V	CO 6	T2: 10.4,T2: 14.1– 14.4

Signature of Course Coordinator **HOD,AE**
Dr K.Srinivasa Reddy Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**ENGINEERING PHYSICS LABORATORY**				
Course Code	AHS105				
Program	B.Tech				
Semester	II	AE			
Course Type	FOUNDATION				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Mr. K Saibaba, Assistant Professor				

I COURSE OVERVIEW:

This lab course provides hands on experience in a number of experimental techniques and developscom-petenceintheinstrumentationtypicallyusedinphysics.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	2

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Engineering 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:

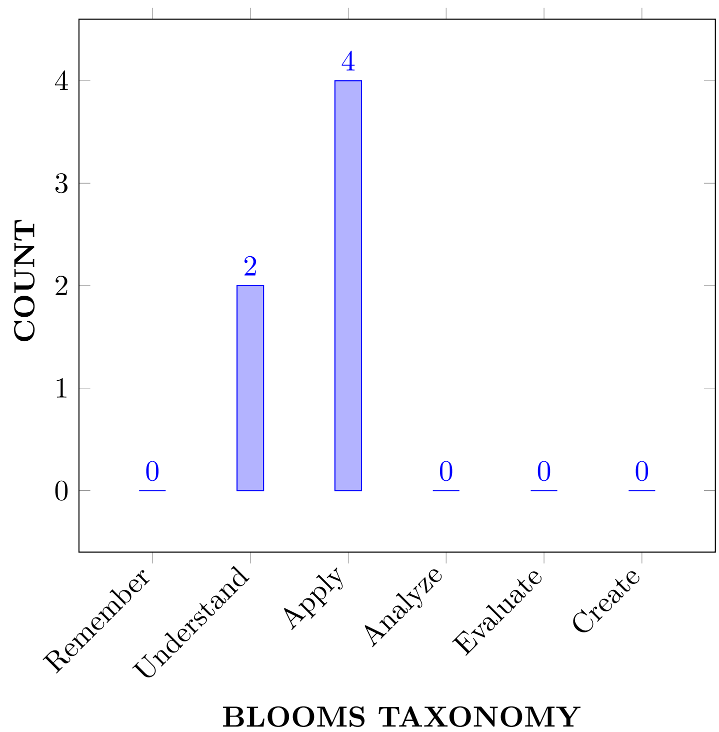
I	To familiarize with the lab facilities, equipment, standard operating procedures.
II	About the different kinds of functional electric and magnetic materials which paves a way for them to use in various technical and engineering applications.
III	The analytical techniques and graphical analysis to study 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	**Interpret** the least count values of Vernier calipers and Screw guage Apply the concept of hook's law and determine the rigidity modulus of wire.	Apply
CO 2	**Illustrate** principle, working and application of wave propagation and compare results with theoretical harmonics and overtones.	Understand
CO 3	**Investigate** the magnetic field induction produced at various points along the axis of current carrying coil and the magnetic field produced in a coil to verify the Tangent's law.	Apply
CO 4	**Examine** launching of light through optical fiber from the concept of light gathering capacity of numerical aperture.	Understand
CO 5	**Utilize** the method of minimum deviation and adjust the spectrometer to minimum deviation position also determine the dispersive power of prism by using spectrometer.	Apply
CO 6	**Investigate** V-I/L-I characteristics of various optoelectronic devices like Light Emitting Diode, Laser diode to understand their basic principle of functioning	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 Vernier caliperse and screw guage to determine their least count values and also finding the rigidity modulus of given wire.	2
	PO 2	Understand the Hoocks law and the rigidity modulus finding by using the given wire and bross or any metal disk .	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 method of minimum deviation position and also determine the dispersive power of prism by using spectrometer. and adjust the spectrometer to minimum deviation position	2
	PO 2	Investigate the method of minimum deviation position and also determine the dispersive power of prism by using spectrometer. and adjust the spectrometer to minimum deviation position	4
	PO 4	Apply the concept of Newton's rings to determine the radius of curvature of convex lens	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	Determine the thickness of a wire and radius of a disc using screw gauge and vernier calipers	1
CO 6	PO 1	Explain the V-I characteristics of light emitting diode with different colours of LEDs for different threshold voltage values.	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 Laser 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 2
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	**MEASUREMENT OF THICKNESS OF A WIRE AND RADIUS OF DISC**
	Determine the thickness of a wire and radius of a disc using screw gauge and vernier calipers .
WEEK 2	**TORSIONAL PENDULUM**
	Determination of rigidity modulus of the material of given wire using a torsional pendulum .
WEEK 3	**STEWART GEE'S APPARATUS**
	Determination of Magnetic field along the axis of current carrying coil – Stewart and Gee's method.
WEEK 4	**DETERMINATION OF FREQUENCY OF LONGITUDINAL WAVES**
	Determination of frequency of a given tuning fork in longitudinal mode.
WEEK 5	**DETERMINATION OF FREQUENCY OF TRANSVERSE WAVES**
	Determination of frequency of a given tuning fork in transverse mode.
WEEK 6	**WAVELENGTH OF LASER SOURCE-DIFFRACTION GRATING**
	To determine the wavelength of given source of laser using a plane transmission grating.
WEEK 7	**ADJUSTMENT AND MINIMUM DEVIATION IN SPECTROMETER**
	To study about spectrometer and to adjust spectrometer in minimum deviation position.
WEEK 8	**DISPERSIVE POWER OF A MATERIAL OF PRISM**
	Determination of the dispersive power the material of the given prism.
WEEK 9	**NEWTONS RINGS**
	Determination of radius of curvature of a given plano-convex lens.
WEEK 10	**NUMERICAL APERTURE OF GIVEN FIBER**
	To determine the numerical aperture of a given optical fiber.
WEEK 11	**LIGHT EMITTING DIODE**
	Studying V-I characteristics of LED
WEEK 12	**CHARACTERISTICS OF LASER DIODE**
	To study L-I characteristics of a laser diode.

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	Determine the thickness of a wire and radius of a disc using screw gauge and vernier calipers .	CO 1	T1:13.5
2	Determination of rigidity modulus of the material of given wire using a torsional pendulum .	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 frequency of a given tuning fork in longitudinal mode.	CO 3	T1:15.7
5	Determination of frequency of a given tuning fork in transverse mode.	CO 1	T1:16.8
6	To determine the wavelength of given source of laser using a plane transmission grating.	CO 6	T1:16.9
7	To study about spectrometer and to adjust spectrometer in minimum deviation position.	CO 4	T1:17.9
8	Determination of the dispersive power the material of the given prism.	CO 5	T1:18.10
9	Determination of radius of curvature of a given plano-convex lens.	CO 6	T1:19.10
10	Determine the numerical aperture of a given optical fiber.	CO 6	T1:19.9
11	Studying V-I characteristics of LED	CO 5	T1:23.10
12	Study L-I characteristics of a laser diode.	CO 5	T1:23.10

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	To determine the width of slit by using Laser light source by diffraction method
2	To study the bending losses and transmission losses of an optical Fiber
3	To Calculate carrier concentration og given semiconductor by using Hall Effect.
4	Study the characteristics of Photo diode.
5	To illustrate the interference pattern produced from the air wedge.
6	To determine energy loss of ferromagnetic material

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

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(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**ENGINEERING MECHANICS**				
Course Code	AME002				
Program	B. Tech				
Semester	TWO				
Course Type	Foundation				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. B D Y Sunil, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS002	1	Linear Algebra and Ordinary Differential Equations

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). 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
%	Remember
%	Understand
%	Apply
%	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:

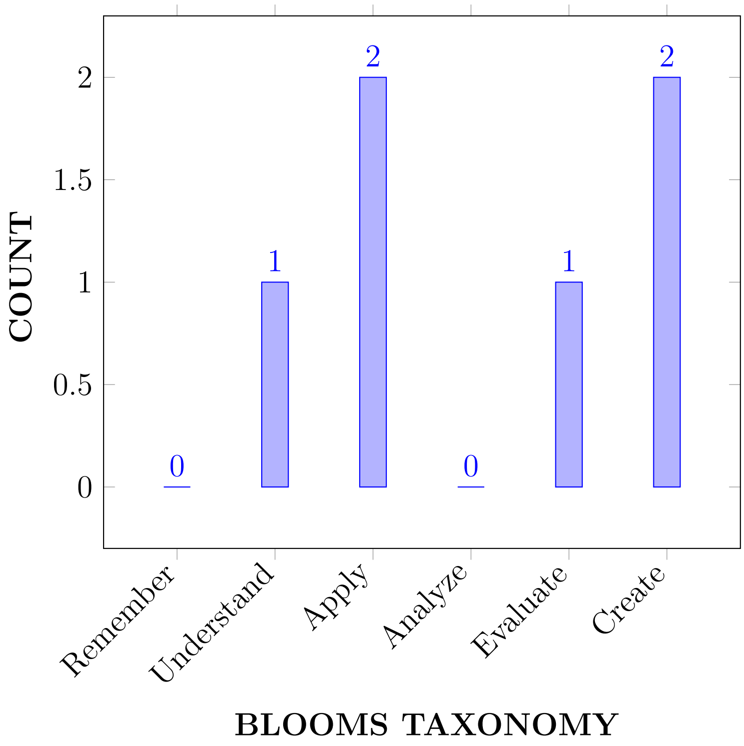
I	Develop the ability to work comfortably with basic engineering mechanics concepts required for analyzing dynamic structures.
II	Identify an appropriate structural system to studying a given problem and isolate it from its environment, model the problem using good free-body diagrams and accurate equilibrium equations.
III	Identify and model various types of loading and support conditions that act on structural systems, apply pertinent mathematical, physical and engineering mechanical principles to the system to solve and analyze the problem .
IV	Understand the meaning of impulse and momentum, virtual work and solve the field problems .
V	Solve the problem of equilibrium by using the principle of work and energy and vibrations for preparing the students for higher level courses such as, Mechanics of Solids, Mechanics of Fluids etc .

VII COURSE OUTCOMES:

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

CO 1	**Make use of** principles for rectilinear motion of particles to solve problems in motion curves, rigid body motion and fixed axis rotation.	Apply
CO 2	**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 3	**Develop** the relations for the motion of body in lift and on inclined plane to identify the unknown forces and the forces due to gravity.	Create
CO 4	**Understand** the concept of virtual work to solve problems involving displacements and time with respect to impact and impulse momentum equation.	Understand
CO 5	**Determine** the effect of law of conversation of energy when the system involves before and after collision.	Evaluate
CO 6	**Develop** the governing equation for momentum and vibrational phenomenon of mechanical system by using energy principles for obtaining co efficient and circular frequency.	Create

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.	1	[CIE/Quiz/AAT]
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Seminar/ Conferences / Research papers

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Apply the knowledge and principals of mathematics to engineering problems for determining reactions and resultants of forces using the knowledge of mathematics and science fundamentals	2
	PO 2	Analyze and formulate the engineering problems to determine the reactions and resultants of given force systems. Analyze and identify the problem statement, formulation and abstraction for the development of solution.	4
CO2	PO 2	Collect the data from complex engineering problems and implement them to draw the free body diagrams and interpret the results	3
CO 3	PO 2	Formulate the force system of friction problem and identify the appropriate equilibrium equation and develop the solution from the first principles of mathematics.	4
	PO 4	Understand the principles of engineering and apply them to the friction systems by analyzing the condition of motion of rest of the body	2

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 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	**KINEMATICS OF PARTICLES- RECTILINEAR MOTION**
	Motion of a particle – Rectilinear motion – motion curves – Rectangular components of curvilinear motion Kinematics of Rigid Body - Types of rigid body motion - Angular motion - Fixed Axis Rotation .
MODULE II	**KINETICS OF PARTICLE**
	Introduction-Definitions of Matter, body, particle, mass, weight, inertia, momentum. Newton's law of motion. Relation Between force and mass. Motion of a particle in rectangular coordinates. D'Alembert's Principle.Motion of Lift. Motion of body on an inclined plane. Motion of connected Bodies.
MODULE III	**IMPULSE AND MOMENTUM, VIRTUAL WORK**
	IMPULSE AND MOMENTUM Impulse And Momentum: Introduction-Impact, Momentum, Impulse and Impulsive forces, Units. Law of conservation of Momentum, Newton's law of collision of elastic bodies-coefficient of Restitution. Recoil of Gun. Impulse Momentum Equation. VIRTUAL WORK: Introduction – Principle of virtual work – Applications – Beams, Lifting machines, Simple framed structures
MODULE IV	**WORK ENERGY METHOD**
	Law of conservation of Energy, Application of Work Energy Method to particle motion and connected system- Work energy applied to Connected Systems - Work energy applied to Fixed Axis Rotation.

MODULE V	**MECHANICAL VIBRATIONS**
	Definitions and Concepts – Simple Harmonic Motion – Free vibrations, simple and Compound Pendulums – Torsion Pendulum – Free vibrations without damping: General cases.

TEXTBOOKS

1. R.C. Hibbler, “Engineering Mechanics”, Prentice Hall, 12th Edition, 2009.
2. Engineering Mechanics - Statics and Dynamics by Ferdinand.L. Singer / Harper International Edition.
3. Engineering Mechanics/ S. Timoshenko and D.H. Young, Mc Graw Hill Book Company.

REFERENCE BOOKS:

1. S. Bhavikatti, “A Text Book of Engineering Mechanics”, New Age International, 1st Edition, 2012.
2. A.K Tayal ,“Engineering Mechanics”, Uma Publications, 14th Edition, 2013.
3. R.K. Bansal “Engineering Mechanics”, Laxmi Publications, 8th 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.

S.No	Topics to be covered	CO’s	Reference
OBE DISCUSSION			
1	Discussion on Objectives and Outcomes of the course Engineering Mechanics		
CONTENT DELIVERY (THEORY)			
1	Introduction to motion of a particle	CO 1	T2:5.5 R1:1.12.1
2	Rectilinear motion	CO 1	T2:5.6 R1:1.12.3
3	Motion curves	CO 1	T2:5.10 R1:1.15
4	Rectangular components of curvilinear motion	CO 1	T2:5.15 R1:1.16
5	Difference between rectilinear motion and curvilinear motion	CO 1	T2:5.17 R1:1.13.1
6	Kinematics of Rigid Body	CO 1	T2:5.18 R1:1.13.2
7	Types of rigid body motion	CO 1	T2:5.19 R1:1.13.3
8	Angular motion	CO 1	T2:5.20 R1:1.7.1

9	Fixed Axis Rotation	CO 1	T2:5.24 R1:1.17.3
10	Introduction to kinetics	CO 2	T2:6.3 R1:2.6.1
11	Definitions of Matter, body, particle, mass, weight, inertia, momentum	CO 2	T2:6.5 R1:2.6.2
12	Newton's law of motion	CO 2	T2:5.5 R1:1.12.1
13	Relation Between force and mass	CO 2	T2:5.6 R1:1.12.3
14	Motion of a particle in rectangular coordinates	CO 2	T2:5.10 R1:1.15
15	D'Alembert's Principle.Motion of Lift	CO 2	T2:5.15 R1:1.16
16	Motion of body on an inclined plane, motion of connected Bodies	CO 2	T2:5.17 R1:1.13.1
17	Impulse And Momentum: Introduction- Impact, Momentum	CO 3	T2:5.18 R1:1.13.2
18	Impulse and Impulsive forces, Units	CO 3	T2:5.19 R1:1.13.3
19	Law of conservation of Momentum, Newton's law of collision of elastic bodies- coefficient of Restitution	CO 3	T2:5.20 R1:1.7.1
20	Recoil of Gun. Impulse Momentum Equation	CO 3	T2:5.24 R1:1.17.3
21	Introduction to virtual work	CO 4	T2:5.5 R1:1.12.1
22	Principle of virtual work – Applications	CO 4	T2:5.6 R1:1.12.3
23	Beams, Lifting machines	CO 4	T2:5.10 R1:1.15
24	Simple framed structures	CO 4	T2:5.15 R1:1.16
25	Introduction to work energy method	CO 5	T2:5.17 R1:1.13.1
26	Law of conservation of Energy	CO 5	T2:5.18 R1:1.13.2
27	Applications of Work Energy Method	CO 5	T2:5.19 R1:1.13.3
28	Applications of Work Energy Method to particle motion	CO 5	T2:5.20 R1:1.7.1
29	Applications of Work Energy Method to connected system	CO 5	T2:5.24 R1:1.17.3
30	Work energy applied to Connected Systems	CO 5	T2:6.3 R1:2.6.1
31	Work energy applied to Fixed Axis Rotation	CO 5	T2:6.5 R1:2.6.2
32	Introduction to mechanical vibrations	CO 6	T2:5.5 R1:1.12.1

33	Definitions and Concepts	CO 6	T2:5.6 R1:1.12.3
34	Simple Harmonic Motion	CO 6	T2:5.10 R1:1.15
35	Free vibrations	CO 6	T2:5.15 R1:1.16
36	Simple pendulum	CO 6	T2:5.17 R1:1.13.1
37	Compound pendulum	CO 6	T2:5.18 R1:1.13.2
38	Torsional pendulum	CO 6	T2:5.19 R1:1.13.3
39	Free vibrations without damping	CO 6	T2:5.20 R1:1.7.1
40	Free vibrations without damping general cases	CO 6	T2:5.24 R1:1.17.3
PROBLEM SOLVING/ CASE STUDIES			
1	Rectilinear motion of a particle	CO 1	T2:5.5 R1:1.12.1
2	Kinematics of Rigid Body	CO 1	T2:5.6 R1:1.12.3
3	Fixed Axis Rotation	CO 1	T2:5.10 R1:1.15
4	D'Alembert's Principle	CO 2	T2:5.15 R1:1.16
5	Motion of Lift	CO 2	T2:5.17 R1:1.13.1
6	Motion of body on an inclined plane	CO 2	T2:5.18 R1:1.13.2
7	Motion of connected Bodies	CO 2	T2:5.19 R1:1.13.3
8	Impact, Momentum, Impulse and Impulsive forces	CO 3	T2:5.20 R1:1.7.1
9	Newton's law of collision of elastic bodies	CO 3	T2:5.24 R1:1.17.3
10	Applications – Beams, Lifting machines, Simple framed structures	CO 4	T2:6.3 R1:2.6.1
11	Work energy applied to Connected Systems	CO 5	T2:6.5 R1:2.6.2
12	Work energy applied to Fixed Axis Rotation	CO 5	T2:5.5 R1:1.12.1
13	Simple Harmonic Motion	CO 6	T2:5.6 R1:1.12.3
14	simple and Compound Pendulums	CO 6	T2:5.10 R1:1.15
15	Torsion Pendulum	CO 6	T2:5.15 R1:1.16

DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Module – 1 – Kinematics of Particles - Rectilinear Motion	CO 1	T2:5.5 R1:1.12.1
2	Module – 2 – Kinetics of Particle	CO 2	T2:5.6 R1:1.12.3
3	Module – 3 – Impulse and Momentum, Virtual Work	CO 3, CO4	T2:5.10 R1:1.15
4	Module – 4 – Work Energy Method	CO 5	T2:5.15 R1:1.16
5	Module – 5 – Mechanical Vibrations	CO 6	T2:5.17 R1:1.13.1
DISCUSSION OF QUESTION BANK			
1	Module – 1 – Kinematics of Particles - Rectilinear Motion	CO 1	T2:5.5 R1:1.12.1
2	Module – 2 – Kinetics of Particle	CO 2	T2:5.6 R1:1.12.3
3	Module – 3 – Impulse and Momentum, Virtual Work	CO 3, CO4	T2:5.10 R1:1.15
4	Module – 4 – Work Energy Method	CO 5	T2:5.15 R1:1.16
5	Module – 5 – 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

<table>
<tr><td>Course Title</td><td colspan="5">MATHEMATICAL TRANSFORM TECHNIQUES</td></tr>
<tr><td>Course Code</td><td colspan="5">AHSC07</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester, Branch</td><td colspan="5">SECOND</td></tr>
<tr><td>Course Type</td><td colspan="5">Foundation</td></tr>
<tr><td>Regulation</td><td colspan="5">IARE – R20</td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lectures</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>3</td><td>1</td><td>4</td><td>-</td><td>-</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Dr. S Jagadha, Associate Professor</td></tr>
</table>

I. 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.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
10+2	AHSC07	Second	Basic principles of Mathematics

III. MARKS DISTRIBUTION:

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

IV. DELIVERY / INSTRUCTONAL METHODOLOGIES:

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

V. EVALUATION METHODOLOGY:

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

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

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

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

Continuous Internal Assessment (CIA):

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

Table 2: Assessment pattern for CIA

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

Continuous Internal Examination (CIE):

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

Quiz –Online Examination:

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

Alternative Assessment Tool (AAT):

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

Table 3: Assessment pattern for AAT

Concept Videos	Assignment	Tech-talk	Seminar	Open Ended Experiment
20%	30%	30%	10%	10%

VI.COURSEOBJECTIVES:

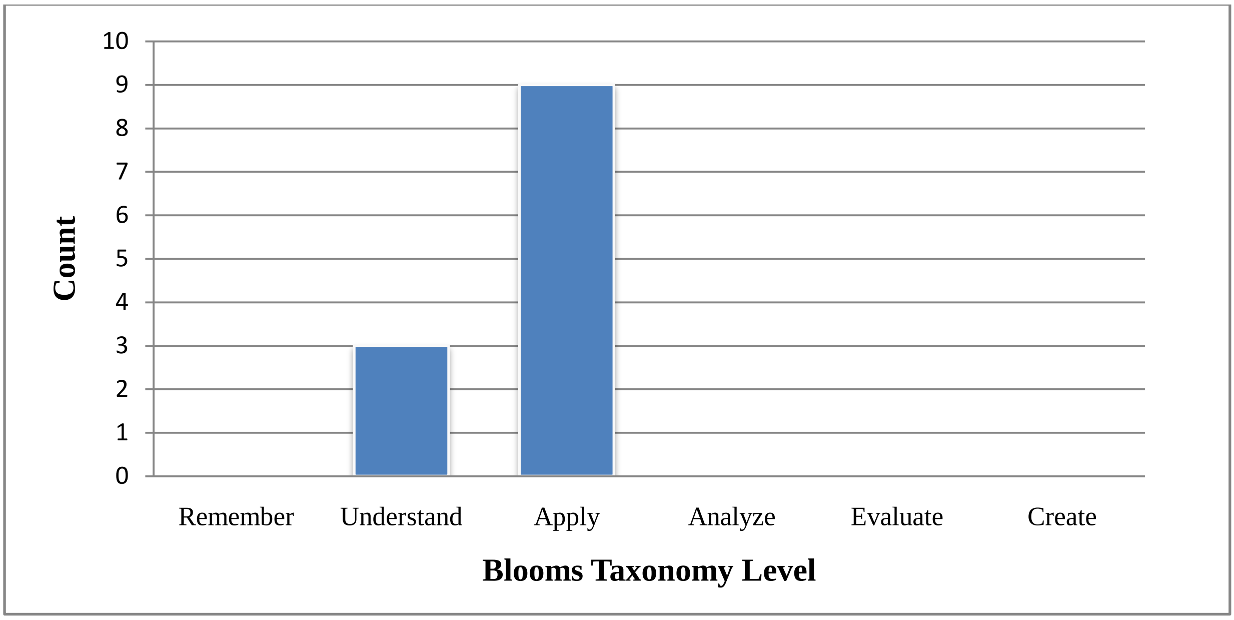
The students will try to learn:	
I	The transformation of ordinary differential equations in Laplace field and its applications
II	The operation of non-periodic functions by Fourier transforms.
III	The concepts of multiple integration for finding areas and volumes of physical quantities
IV	The Integration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

VII.COURSE OUTCOMES:

After successful completion of the course, students will be able to:		
	Course Outcomes	**Knowledge Level (Bloom's Taxonomy)**
CO 1	**Describe** the Laplace and inverse transform to various functions such as continuous, piecewise continuous, step and impulsive functions.	Understand
CO 2	**Interpret** the properties of Laplace and inverse Laplace transform for a function of a real variable 't' (time) to a function of a complex variable's' (complex frequency).	Apply
CO 3	**Make use of** the integral transforms which converts operations of calculus to algebra in solving linear differential equations	Apply

CO 4	**Describe** the Fourier transform as a mathematical function which transforms a signal from the time domain to the frequency domain	Understand
CO 5	**Interpret** the range of non-periodic functions up to infinity by Fourier integral and Fourier transform	Apply
CO 6	**Identify** the properties of complex Fourier transform which intensifies the boundary value problems related to engineering	Apply
CO 7	Apply the definite integral calculus to a function of two or more variables in calculating the area of solid bounded regions	Apply
CO 8	**Develop** the differential calculus which transforms vector functions, gradient. Divergence and curlto the real world engineering problems	Apply
CO 9	**Apply** the integral transformations to surface and volume, line and surface of different geometrical models in the domain of engineering	Apply
CO 10	**Apply** integral theorems to different bounded regions in calculating areas	Apply
CO 11	**Explain** Lagrange's linear equation related to dependent and independent variables using partial derivatives to the physical problems of engineering	Understand
CO 12	**Solve** the nonlinear partial differential equation by the method of Charpit concern to engineering field	Apply

KNOWLEDGE COMPETENCY LEVELS:



VIII.HOW PROGRAM OUTCOMES ARE ASSESSED:

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

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

3 = High; 2 = Medium; 1 = Low

IX. HOW PROGRAM SPECIFIC OUTCOMES AREASSESSED:

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

3= High; 2 = Medium; 1 = Low

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

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

CO 9	-	√	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 10	-	√	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 11	√	√	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 12	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-

XI. JUSTIFICATIONS FOR CO – PO MAPPING:

Course Outcomes	POs / PSOs	Justification for mapping (Students will be able to)	No. of key competencies
CO1	**PO 1**	Describe the Laplace and inverse transform (understand) to **complex engineering problems** of various functions such as continuous, piecewise continuous, step and impulsive functions with **principle of mathematics.**	**2**
CO2	**PO 1**	Interpret the properties of Laplace and inverse Laplace transform (apply)in solving **complex engineering problems** for a function of a real variable ‘t’ (time) (apply) to a function of a complex variable ‘s’ (complex frequency**) with basic Principle of mathematics to** reach valid conclusions of engineering problems	**2**
CO3	**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	**4**
	PO 4	Explain the integral transforms in solving ordinary differential equations will be **quantitatively measured** by using **MATLAB computer software.**	**1**
	PSO 1	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**.	**1**
CO4	**PO 1**	Describe the mathematical function as a signal form from the time domain to the frequency domain in the **complex engineering** problems by (apply) Fourier transformation. **(Principle of Mathematics**)	**2**
CO5	**PO 2**	Apply the Fourier transform as a **formulation** of mathematical function in **complex engineering problems** which transforms a non-periodic functions using **principles of mathematics** to attain conclusions by the **interpretation of results**	**4**
CO6	**PO 2**	Identify the **statement of** properties of complex Fourier transform (understand)in **complex engineering problems** which intensifies (apply) the boundary value problems using **principle of mathematics** related to engineering by **the interpretation of results.**	**4**
	PSO 1	Identify the properties of complex Fourier transform concern Aeronautical Engineering which intensifies (apply) the boundary value problems in **the design and implementation of complex systems.**	**1**

CO7	**PO 2**	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.**	**4**
CO8	**PO 2**	Develop the **statement and formulation** of differential calculus of **complex engineering problems** which transforms vector functions, gradient. Divergence and curl using **principle of mathematics t**o the real world engineering problems by **interpretation of results.**	**4**
CO9	**PO 2**	Apply the **formulation** of integral transformations to **complex engineering problems** related to surface and volume, line and surface of different geometrical models using **principle of mathematics** in the domain of engineering to reach conclusions by **interpretation of results.**	**4**
CO 10	**PO 2**	Apply the **formulation** of integral theorems to **complex engineering problems** related to bounded regions of different geometrical models using **principle of mathematics to** calculate areas by **interpretation of results.**	**4**
CO11	**PO 1**	Describe Lagrange's linear equation related to **complex engineering problems** such as dependent and independent variables (understand) using partial derivatives to the physical problems of engineering**(Principle of Mathematics**)	**2**
	PO 2	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**.	**4**
CO12	**PO 1**	Apply the method of Charpit to **complex engineering problems** such as nonlinear PDE equations in the domain of engineering **(Principle of engineering)**	**2**

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

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

CO 8	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 9	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 10	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 11	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 12	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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

Course Outcomes	**Program Outcomes /No. of key competencies**												**PSO /No. of key competencies**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
	3	**10**	**10**	**11**	**1**	**5**	**3**	**3**	**12**	**5**	**12**	**12**	**2**	**2**	**2**
CO 1	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 2	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 3	0.0	40.0	0.0	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0
CO 4	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 5	0.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 6	0.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0
CO 7	0.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 8	0.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 9	0.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 10	0.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 11	66.7	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 12	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

XIV.COURSE ARTICULATION MATRIX (PO – PSO MAPPING)

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

0 – **0**≤ C≤ 5%–No correlation

1 – 5 <C≤ 40%– Low/ Slight

2 − 40 % <C< 60% –Moderate

3 – 60% ≤ C< 100% – Substantial /High

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	2	-	1	-	-	-	-	-	-	-	-	2	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	-	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 7	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 8	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 9	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 10	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 11	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 12	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	15	16	-	1	-	-	-	-	-	-	-	-	4	-	-
AVERAGE	**3**	**2**	-	**1**	-	-	-	-	-	-	-	-	**2**	-	-

XV. ASSESSMENT METHODOLOGIES–DIRECT

CIE Exams	PO 1,PO 2, PO 4	SEE Exams	PO 1,PO 2, PO 4	Tech Talk Concept Video	-	Seminars	PO 1,PO 2, PO 4
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO 1,PO 2, PO 4						

XVI. ASSESSMENT METHODOLOGIES–INDIRECT

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

XVII. SYLLABUS

MODULE-I	**LAPLACE TRANSFORMS**	**Classes: 09**
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**	**Classes: 09**
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**	**Classes: 09**
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**	**Classes: 09**
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**	**Classes: 09**
Formation of partial differential equations by elimination of arbitrary constants and arbitrary functions, solutions of first order linear equations; Charpit’s method;		
TEXT BOOKS:		
1. B.S. Grewal, “Higher Engineering Mathematics”, Khanna Publishers, 36th 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”, John Wiley & Sons, 9th Edition, 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, 2nd Edition, 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/resources/#Mathematics 3. http://www.sosmath.com 4. http://www.mathworld.wolfram.com		
E-TEXT BOOKS:		
1. http://www.e-booksdirectory.com/details.php?ebook=10166 2. http://www.e-booksdirectory.com/details.php?ebook=7400re		

XVIII. COURSE PLAN:

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

Lecture No	Topics to be covered	Course Outcomes	Reference
1	Define Laplace transform and its properties	CO 1	T1:21.1,21.4 R1:5.1
2	Define Piecewise continuous function, Existence of Laplace transform, Function of exponential order	CO 1	T1:21.2 R1:5.1
3	Apply Shifting theorems, Change of scale property of Laplace transform to given function	CO 1	T1:21.4 R1:5.1
4	Apply Laplace transforms of derivatives and integrals, multiplied by t, divided by t to a given function	CO 2	T1:21.7-21.10 R1:5.2-5.4
5	Define Inverse Laplace transform	CO 1	T1:21.12 R1:5.1,5.6
6	Apply shifting theorem, change of scale property of inverse Laplace transform to the given function	CO 2	T1:21.13 R1:5.1,5.3
7	Apply multiplied by s, divided by s of Laplace transform to the given function	CO 2	T1:21.13 R1:5.4
8-9	Apply Convolution theorem to the given function	CO 3	T1:21.14 R1:5.5
10-11	Define Fourier integral theorem	CO 4	T1:22.1-22.2 R1:10.8
12-13	Apply Fourier sine and cosine integrals to the given functions	CO 4	T1:22.3 R1:10.8
14-15	Define Fourier transforms	CO 4	T1:22.4 R1:10.9
16-17	Apply suitable properties to solve the given functions	CO 6	T1:22.5 R1:10.9
18	Apply Inverse transforms and finite Fourier transforms to the given function	CO 5	T1:22.4 R1:10.9
19-20	Calculate double and triple integrals of a function in Cartesian form and Polar form.	CO 7	T2:15.5 R1:7.5
21-23	Apply Change of order of integrations to Cartesian and polar form.	CO 7	T2:16.5 R1:7.6
24-25	Transform coordinate system to find double integral.	CO 7	T2:16.5 R1:7.6
26	Apply double integration to find the area of the bounded region	CO 7	T2:10.1 R1:16.1
27	Apply triple integration to find the volume.	CO 7	T2:10.1 R1:16.2
28	Define vector calculus and vector fields and their properties.	CO 8	T2:10.3 R1:16.4
29	Describe Solenoidal and irrotational vector point function.	CO 8	T2:11.3 R1:16.5
30	Calculate line integral along smooth path and find work done.	CO 9	T2:11.3 R1:16.5
31-33	Calculate the surface area and volume of field.	CO 9	T2:11.3 R1:16.5
34	Apply Green's theorem to solve line integrals along simple closed contours on the plane.	CO 10	T2: 11.3 R1:16.11
35	Apply Stokes' theorem to give a physical interpretation of the curl of a vector field.	CO 10	T2: 11.3 R1:16.9

Lecture No	Topics to be covered	Course Outcomes	Reference
36	Apply Gauss divergence theorem to give a physical interpretation of the divergence of a vector field.	CO 10	T2: 11.4 R1:16.18
37-39	Formulate partial differential equations by elimination of arbitrary constants and arbitrary functions	CO 11	T1:17.1-17.2 R1:16.1-16.2
40-42	Solve first order linear equation by Lagrange's method	CO 11	T1:17.5-17.6 R1:16.3.1
43-45	Solve first order nonlinear equation by Charpit method	CO 12	T1:17.1-17.2 R1:16.1-16.2

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

S No	Description	Proposed Actions	Relevance with POs
1	Newton Raphson method, Lagranges interpolation, method of least square and Runge-kutta method	Seminars/NPTEL	PO 2
2	Fourier Integral Transforms, Convolution theorem in Fourier Transforms	Seminars	PO 1
3	Encourage students to solve real time applications and prepare towards competitive examinations	NPTEL	PSO 1

Prepared by
Dr. S Jagadha, Associate Professor **HOD, AE**

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

COMPUTER SCIENCE AND ENGINEERING

COURSE DESCRIPTION

<table>
<tr><td>Course Title</td><td colspan="6">PROGRAMMING FOR PROBLEM SOLVING LABORATORY</td></tr>
<tr><td>Course Code</td><td colspan="6">ACS101</td></tr>
<tr><td>Program</td><td colspan="6">B.Tech</td></tr>
<tr><td>Semester</td><td>I</td><td colspan="5">CSE |IT |ECE |EEE |MECH |AERO</td></tr>
<tr><td>Course Type
Regulation</td><td>Foundation
IARE - R16</td><td colspan="5"></td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>3</td><td>1.5</td></tr>
<tr><td>Course Coordinator</td><td colspan="6">Mr,Ravinder, Assistant Professor</td></tr>
</table>

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.

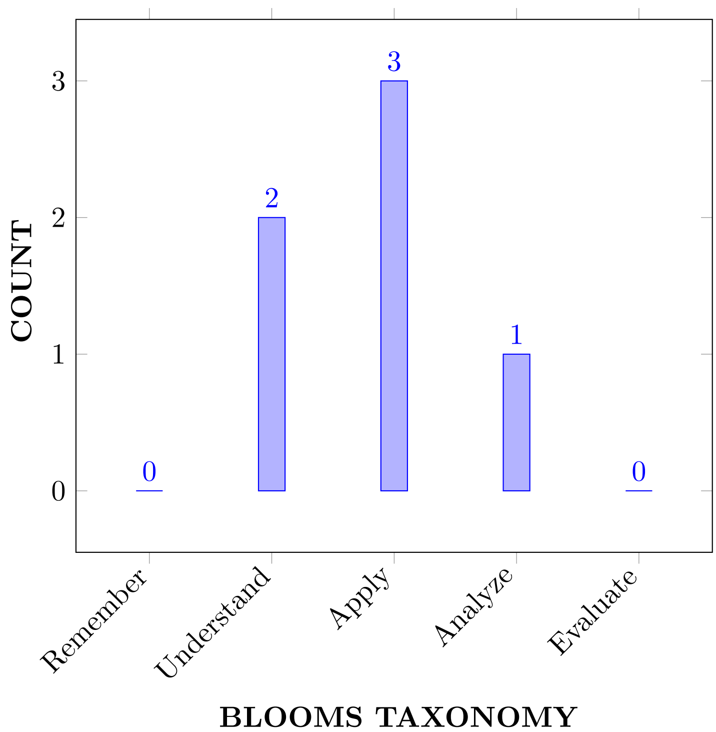
II	The demonstration knowledge of basic abstract data types (ADT) and associated algorithms for organizing programs into modules using criteria that are based on the data structures of the program.
III	The practical implementation and usage of non linear data structures for solving problems of different 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



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	**Professional Skills:** The ability to research, understand and implement computer programs in the areas related to algorithms, system software, multimedia, web design, big data analytics, and networking for efficient analysis and design of computer-based systems of varying complexity. .	2	Viva-voce Laboratory Practices

PSO 2	**Software Engineering Practices:** The ability to apply standard practices and strategies in software service management using open-ended programming environments with agility to deliver a quality service for business success .	2	Viva-voce Laboratory Practices
PSO 3	**Successful Career and Entrepreneurship:** The ability to employ modern computer languages, environments, and platforms in creating innovative career paths, to be an entrepreneur, and a zest for higher studies. .	2	Viva-voce Laboratory Practices

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Understand (knowledge) the basic concept of algorithm analysis which provides theoretical estimates for the resources needed by any algorithm for a given computational problem. These estimates provide an insight into reasonable directions of search for efficient algorithms by applying the principles of **mathematics and science**	3
	PO 5	Understand the (given **knowledge**) appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	3
CO 2	PO 1	Understand (knowledge)the basic concept of algorithm analysis which provides theoretical estimates for the resources needed by any algorithm for a given computational problem. These estimates provide an insight into reasonable directions of search for efficient algorithms by applying the principles of **mathematics and science.**	3
	PO 5	Understand the (**knowledge**) appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	2
CO 3	PO 1	Understand (**knowledge**) the basic concept of algorithm analysis which provides theoretical estimates for the resources needed by any algorithm for a given computational problem. These estimates provide an insight into reasonable directions of search for efficient algorithms by applying the principles of **mathematics and science.**	3
	PO 5	Understand the (knowledge) appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	3

CO 4	PO 1	Describe (knowledge) the use sorting techniques as a basic building block in algorithm design and problem solving **using principles of mathematics, science, and engineering fundamentals.**	3
	PO 5	Understand the **knowledge** appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	2
	PO 10	Apply (knowledge) concept of dimensional analysis and similarity parameters for predicting physical parameters (understanding) for the fluid flow analysis used in designing prototypes devices (apply) solving design problems by applying the **communicating effectively with engineering community.**	3
CO 5	PO 1	Outline the importance of searching algorithms to retrieve an element from any data structure where it is stored by **understanding and applying the fundamentals of mathematics, science and engineering.**	3
	PO 10	Understand the use of searching techniques that retrieve information stored within some data structure by **communicating effectively with engineering community**.	2
CO 6	PO 1	Outline the importance of searching algorithms to retrieve an element from any data structure where it is stored by **understanding and applying the fundamentals of mathematics, science and engineering**	2
	PO 10	Understand the use of searching techniques that retrieve information stored within some data structure by **communicating effectively with engineering communit.**	3
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
	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
CO 12	PO 1	Build strong foundation of quickly determining the efficiency of an algorithm or data structure for solving computing problems with respect to performance by using knowledge of mathematics, science and engineering fundamentals.	3
	PO 2	Recognize the importance of suitable data structures in checking the efficiency of algorithms used for complex engineering problems.	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 1	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
CO 7	3	2	2		2
CO 8	3		3	2	2
CO 9	2	2	3		2
CO 10	2	3	2		2

CO 11	3	2	2		2
CO 12	2	2	3		3

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**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

<table>
<tr><td>Department</td><td colspan="5">Aeronautical Engineering</td></tr>
<tr><td>Course Title</td><td colspan="5">Introduction to Aerospace Engineering</td></tr>
<tr><td>Course Code</td><td colspan="5">AAE001</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td colspan="5">III</td></tr>
<tr><td>Course Type</td><td colspan="5">Core</td></tr>
<tr><td>Regulation</td><td colspan="5">R-16</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">R Sabari Vihar, Assistant Professor</td></tr>
</table>

I COURSE OVERVIEW:

Introduction to Aerospace engineering covers the fundamental concepts, and approaches of aerospace engineering, and are highlighted through lectures on aeronautics, astronautics, and design. Active learning aerospace modules make use of information technology. Student teams are immersed in a hands-on, lighter-than-air (LTA) vehicle design project, where they design, LTA vehicles. The connections between theory and practice are realized in the design exercises. The performance, weight, and principal characteristics of the LTA vehicles are estimated and illustrated using physics, mathematics, and chemistry known to freshmen, the emphasis being on the application of this knowledge to aerospace engineering and design rather than on exposure to new science and mathematics

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AHS007	I	Applied Physics

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Introduction to Aerospace Engineering	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

<table>
<tr><td>✓</td><td>Chalk & Talk</td><td>x</td><td>Quiz</td><td>x</td><td>Assignments</td><td>x</td><td>MOOC</td></tr>
<tr><td>✓</td><td>LCD / PPT</td><td>x</td><td>Seminars</td><td>x</td><td>Mini Project</td><td>✓</td><td>Videos</td></tr>
<tr><td>x</td><td colspan="7">Open Ended Experiments</td></tr>
</table>

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
20%	Remember
50%	Understand
30%	Apply

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:

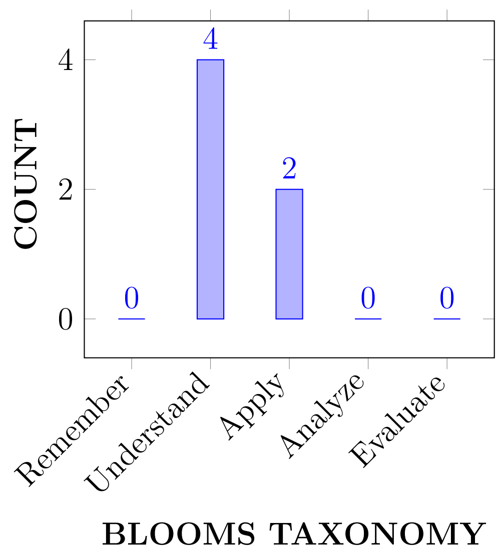
I	Understand the historical evolution of airplane and types of aircrafts along with exploration of space environment.
II	Discuss various aerodynamic forces acting on aircraft components and related principles.
III	Explain the performance and stability of aircraft for different mission segments of flight.
IV	Study the various types of satellite systems and subsystems with human exploration into space.

VII COURSE OUTCOMES:

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

CO 1	**Demonstrate** the various flight vehicles, missiles, and standard atmosphere for updating the status and working knowledge of the flight vehicles.	Understand
CO 2	**Illustrate** the solar system, space environment, and laws of gravitation for the construction of space vehicles.	Understand
CO 3	**Explain** the anatomy of an airplane, aerodynamic forces, and aerofoil characteristics for attaining the aerodynamic characteristics of an aircraft.	Understand
CO 4	**Classify** the types of flight vehicle performance parameters and stability controls for estimating the vehicle attitude and its resulting flight path.	Understand
CO 5	**Make use of** the skeletal structure of an aircraft, materials, basic ideas about engines, and rockets for identifying the development and output performance of the design.	Apply
CO 6	**Apply** the knowledge of subsystems of satellites and space missions for developing the communication between the Earth and the outer atmosphere.	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.	1.9	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.	1.8	CIE/SEE/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/SEE/AAT

3 = High; 2 = Medium; 1 = Low

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.	1.7	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
CO 1	PO 1	Identify the different types of flights, lighter than air vehicles, and helicopters by applying the principles of **mathematics, science and Engineering**	2
CO 2	PO 1	Understand the solar system, space environment and laws for making the space vehicles by applying the **principles of mathematics, science, and engineering fundamentals.**	2
CO 3	PO 1	**Illustrate** (understanding) the parts of the airplane, airfoil nomenclature for gaining the knowledge of aerodynamic characteristics by applying the **principles of mathematics, science and engineering fundamentals**	2
	PO 2	Understand (the given **problem statement and formulate**) the principals of two dimensional flows for determining the aerodynamic characteristics (from the provided **information and data** in reaching conclusions by the interpretation of results)	2
	PO 3	Design a prototype of a infinite wing model by analyzing the fluid flow problems using principles of mathematics and engineering sciences.	2
	PSO2	Apply (the knowledge) for the improvements of infinite wing performance 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	**Demonstrate** (the knowledge) flight vehicle performance parameters for obtaining the desired flight path by applying the principles of **mathematics, science and Engineering**	1
	PO 2	Identify (the given **problem statement and formulate**) the flight parameters, stability control parameters for determining vehicle attitude (from the provided **information and data** in reaching substantiated conclusions by the interpretation of results)	2
	PSO 2	Apply (the knowledge) of flight performance parameters and stability controls for solving the stability control problems by applying the principles of **mathematics, science and Engineering**	2

CO 5	PO 1	Relate (knowledge, understand and apply) the aircraft structure parts, materials required and engines parts by applying the principles of **mathematics, science and engineering fundamentals**.	2
	PO 2	Understand the given problem statement and formulate thrust production for jets and rocket problems from the provided information and data in reaching substantiated conclusions by the interpretation of results.	2
	PSO 2	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**	1
CO 6	PO 1	**Explain** (understanding) the theories of satellite subsystems, different space mission and their application areas related in solving engineering problems by applying the fundamentals and their integration and support with other **engineering disciplines, mathematics, science**	2
	PO2	Understand the given **problem statement and formulate** the (complex) engineering problems of satellite structures, power systems and communications from the provided information and data, develop solutions based on the functionality of the satellite devices substantiated conclusions **by the interpretation of results.**	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	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	2	2	-	-	-	-	-	-	-	-	-	-	2	-
CO 4	1	2	-	-	-	-	-	-	-	-	-		-	2	-
CO 5	2	2	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 6	2	1	-	-	-	-	-	-	-	-	-		-	-	-

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.7	40	-	-	-	-	-	-	-	-	-	-	-	66.7	-
CO 4	33.3	40	-	-	-	-	-	-	-	-	-		-	66.7	-
CO 5	66.7	40	-	-	-	-	-	-	-	-	-	-	-	33.3	-
CO 6	66.7	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	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	2	2	-	-	-	-	-	-	-	-	-	-	2	-
CO 4	1	2	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 5	2	2	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 6	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	11	7	2	-	-	-	-	-	-	-	-	-	-	5	-
AVERAGE	1.9	1.8	2	-	-	-	-	-	-	-	-	-	-	1.7	-

XVI ASSESSMENT METHODOLOGY DIRECT:

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

XVII ASSESSMENT METHODOLOGY INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**HISTORY OF FLIGHT AND SPACE ENVIRONMENT**
	Balloons and dirigibles, heavier than air aircraft, commercial air transport; Introduction of jet aircraft, helicopters, missiles; Conquest of space, commercial use of space; Different types of flight vehicles, classifications exploring solar system and beyond, a permanent presence of humans in space; Earth‘s atmosphere, the standard atmosphere; The temperature extremes of space, laws of gravitation, low earth orbit, microgravity, benefits of microgravity; Environmental impact on spacecraft, space debris; Planetary environments.
MODULE II	**INTRODUCTION TO AERODYNAMICS**
	Anatomy of the airplane, helicopter; Understanding engineering models; Aerodynamic forces on a wing, force coefficients; Generating lift, moment coefficients; Aerodynamic forces on aircraft – classification of NACA airfoils, aspect ratio, wing loading, mach number, centre of pressure and aerodynamic centre-aerofoil characteristics-lift, drag curves; Different types of drag.
MODULE III	**FLIGHT VEHICLE PERFORMANCE AND STABILITY**
	Performance parameters, performance in steady flight, cruise, climb, range, endurance, accelerated flight symmetric maneuvers, turns, sideslips, takeoff and landing. Flight vehicle Stability, static stability, dynamic stability; Longitudinal and lateral stability; Handling qualities of the airplanes.
MODULE IV	**INTRODUCTION TO AIRPLANE STRUCTURES AND MATERIALS, POWER PLANTS**
	General types of construction, monocoque, semi-monocoque; Typical wing and fuselage structure; Metallic and non-metallic materials, use of aluminum alloy, titanium, stainless steel and composite materials; Basic ideas about engines, use of propeller and jets for thrust production; Principles of operation of rocket, types of rockets.
MODULE V	**SATELLITE SYSTEMS ENGINEERING HUMAN SPACE EXPLORATION**
	Satellite missions, an operational satellite system, elements of satellite, satellite bus subsystems; Satellite structures, mechanisms and materials; Power systems; Communication and telemetry; Propulsion and station keeping; Space missions, mission objectives. Goals of human space flight missions, historical background, the Soviet and US missions; The mercury, Gemini, Apollo (manned flight to the moon), Skylab, apollo-soyuz, space Shuttle; International space station, extravehicular activity; The space suit; The US and Russian designs; Life support systems, flight safety; Indian effort in aviation, missile and space technology.

TEXTBOOKS

1. Anderson, J.D., Introduction to Flight, fifth edition, Tata McGraw-Hill, 2007, ISBN: 0-07-006082-4
2. Newman, D., Interactive Aerospace Engineering and Design, (with software and reference material on CD), McGraw-Hill, 2002, ISBN 0-07-112254-0

REFERENCE BOOKS:

1. Kermode, A. C, —Flight without Formulae, McGraw Hill, 4th Edition, 1997. .
2. Barnard R.H and Philpot. D.R, —Aircraft Fligh, Pearson, 3rd Edition, 2004.
3. Swatton P. J, —Flight Planning, Blackwell Publisher, 6th Edition, 2002.

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 outcomes, program outcomes, Bloom's taxonomy		
CONTENT DELIVERY (THEORY)			
1	Balloons and dirigibles,heavier than air aircraft	CO 1	R2: 3
2	Introduction of jet aircraft, helicopters, missiles;	CO 1	T2: 1.1, 1.2
3	Conquest of space, commercial use of space;	CO 1	T2: 1.1
4	Different types of flight vehicles	CO 1	T2: 1.3
5	classifications exploring solar system and beyond, a permanent presence of humans in space	CO 2	T1: 2.3, T2: 1.2
6	Earth's atmosphere, the standard atmosphere; The temperature extremes of space,	CO 2	T1: 3.1
7	Laws of gravitation, low earth orbit, microgravity, benefits of microgravity;	CO 2	T1: 8.14
8	Environmental impact on spacecraft, space debris; Planetary environments.	CO 2	T1: 8.15
9	Anatomy of the airplane, helicopter;	CO 3	T1: 5.1
10	Understanding engineering models; Aerodynamic forces on a wing, force coefficients;	CO 3	T1: 5.1
11	Generating lift, moment coefficients	CO 3	T1: 5.2
12	Aerodynamic forces on aircraft – classification of NACA airfoils	CO 3	T1: 5.3
13	Aspect ratio, wing loading, mach number	CO 3	T1: 5.4
14	Centre of pressure and aerodynamic centre-aerofoil characteristics-lift,	CO 3	T1: 5.6
15	drag curves; Different types of drag.	CO 3	T1: 5.5, 5.12
16	Performance parameters, Performance in steady flight	CO 4	T1:6
17	Cruise, Climb, Range, Endurance	CO 4	T1:6.7

18	Accelerated flight symmetric maneuvers	CO 4	T1:6.8
19	Turns, sideslips, takeoff and landing.	CO 4	T1:6.10
20	Flight vehicle Stability, static stability,	CO 4	T1:7.2
21	dynamic stability	CO 4	T1: 7.2
22	Longitudinal and lateral stability	CO 4	T1: 7.9
23	Handling qualities of the airplanes.	CO 4	T1: 7
24	General types of construction, monocoque, semi-monocoque;	CO 5	T2:5.3
25	Typical wing and fuselage structure;	CO 5	T2: 5
26	Fuselage structure	CO 5	T2: 5
27	Titanium, stainless steel and composite materials	CO 5	T2: 5.4
28	Basic ideas about engines	CO5	T1: 9
29	Use of propeller and jets for thrust production	CO 5	T1: 9.2
30	Principles of operation of rocket	CO5	T1: 9.4
31	Types of rockets	CO5	T1: 9.3
32	Satellite missions, an operational satellite system	CO 6	T2: 10.1
33	Elements of satellite, satellite bus subsystems	CO 6	T2: 10.3
34	Satellite structures, mechanisms and materials; Power systems; Communication and telemetry	CO 6	T2:10.4
35	Propulsion and station keeping; Space missions, mission objectives	CO 6	T2: 10.5
36	Goals of human space flight missions, historical background	CO 6	T2: 11
37	The Soviet and US missions; The mercury, Gemini, Apollo	CO 6	T2: 11.2
38	Skylab, apollo-soyuz, space Shuttle; International space station, extravehicular activity	CO 6	T2: 11.2.8
39	The space suit; The US and Russian designs; Life support systems	CO 6	T2: 11.4
40	Flight safety; Indian effort in aviation, missile and space technology.	CO 6	T2: 11
PROBLEM SOLVING/ CASE STUDIES			
1	Case studies on Ballons and Dirgibles	CO 1	R2: 3
2	Case studies on Environmental impact on spacecraft	CO 2	T1: 8.15
3	Case studies on Planetary Environments	CO 2	T1: 8.15
4	Problems on lift and drag values	CO 3	T1: 5.3
5	Case study on anatomy of transport and military aircraft	CO 3	T1: 5.1
6	Problems on center of pressure and aerodynamic center	CO 3	T1: 5.6
7	Problems on cruise, climb, range, endurance	CO 4	T1: 6
8	Problems on flight stability control	CO 4	T1: 7.2
9	Case studies on symmetric maneuvers of fighter aircraft	CO 4	T1:6.8

10	Case studies on composite materials required to manufacture aircraft	CO 5	T2: 5.4
11	Case studies on Jet engines	CO 5	T1: 9.4
12	Problems in thrust production	CO 5	T1: 9.2
13	Case studies on Satellite station keeping and subsystems	CO 6	T2: 10.3
14	Case studies on Soviet and US missions	CO 6	T2: 11.2
15	Case studies on Indian effort in aviation and space technology	CO 6	T2: 11
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Types of Flight vehicles, Space debris and orbit, laws of gravitation	CO 1, CO2	T2: 1.3, T1: 8
2	Anatomy of airplane, aerodynamic characteristics of an airfoil	CO 3	T1:8.14, T1: 5
3	Performance Parameters, stability controls	CO 4	T1: 6
4	Fuselage Structure, composite materials and operation of rockets	CO 5	T2: 5.3
5	Elements of Satellite, international space station, space mission objectives	CO 6	T2: 10.3
DISCUSSION OF QUESTION BANK			
1	History of Flight, lighter than aircraft and Space Environment	CO 1, CO 2	T1: 8, 2.3, T2: 1
2	Parts of airplane, aerodynamic characteristics of airfoil	CO 3	T1: 5
3	Flight Vehicles Performance parameters, Stability controls and handling qualities	CO 4	T1: 7
4	Airplane Structures and Materials, Power Plants	CO 5	T1: 9, T2: 10
5	Satellite Systems Engineering and Human Space Exploration, space missions	CO 6	T2: 11

Signature of Course Coordinator **HOD,AE**
R Sabari Vihar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**FLUID MECHANICS AND HYDRAULIC MACHINERY LABORATORY**				
Course Code	AAE102				
Program	B.Tech				
Semester	III				
Course Type	Laboratory				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Dr. Maruthupandiyan K, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAE003	III	Fluid Mechanics and Hydraulic Machines

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 laminar 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

COURSE DESCRIPTION

Department	**Aeronautical Engineering**				
Course Title	**BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Code	AEE018				
Program	B.Tech				
Semester	III	AE/ME/CE			
Course Type	Foundation				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Ms.B Navothna, Assistant Professor,EEE				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS002	I	Linear Algebra and Ordinary Differential Equations
B.Tech	AHS003	I	Computational Mathematics and Integral Calculus

II COURSE OVERVIEW:

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

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two 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
0%	Remember
67%	Understand
33%	Apply
0%	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:

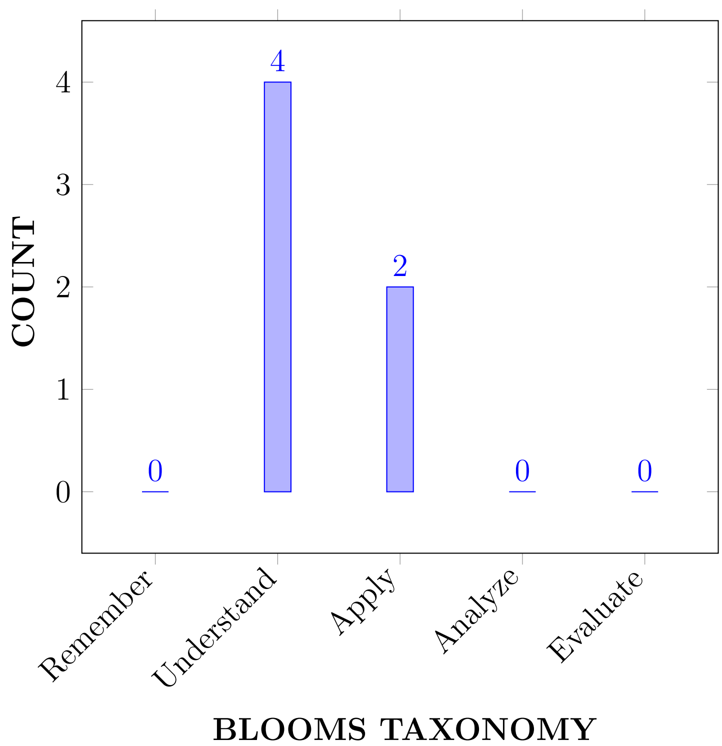
I	Understanding of the basic elements encountered in electric networks, and operation of measuring instruments.
II	The construction and working principle of DC generator, DC motor, andtypes of DC machines based on field excitation method.
III	Analyze the characteristics of alternating quantities and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

VII COURSE OUTCOMES:

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

CO 1	**Solve** complex electrical circuits by applying network reduction techniques for reducing into a simplified circuit.	Apply
CO 2	**Differentiate** the working of moving iron and moving coil type instruments for computing electrical qunatities using suitable instrument.	Understand
CO 3	**Demonstrate** the construction, principle and working of DC machines for their performance analysis.	Understand
CO 4	**Illustrate** alternating quantities of sinusoidal waveform and working , construction of single phase transformers,induction motors, alternators for analysis of AC waveforms and AC machines.	Understand
CO 5	**Apply** the PN junction characteristics for the doide applications such as switch and rectifier.	Apply
CO 6	**Extend** the biasing techniques for bipolar and uni-polar transistor amplifier circuits considering stability condition for establishing a proper operating point.	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	SEE / CIE / AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	SEE / CIE / AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	**PO 1**	Recollect the concept of electricity is described through scientific principles, importance Kirchhoff laws in relation with law of conservation of energy and charge circuits are explained using mathematical principles and various source transformation techniques are adopted for solving complex circuits.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Derive standard expressions for equivalent resistances, inductances and capacitance by using series-parallel networks i.e mathematical calculations.	1
	PSO 1	Solve complex electrical circuits by applying basic circuit concepts by using computer programs.	1
CO 2	**PO 1**	Understand the working principles of indicating instruments and classify types based on construction engineering disciplines.	3
CO 3	**PO 1**	The principle of operation and characteristics of DC machines are explained by applying engineering fundamentals including device physics.	3
CO 4	**PO 1**	Understand about alternating quantities of an AC signal and working of single phase transformers,induction motors and alternators using engineering principles and mathematical equations.	3
	PSO 1	Develop equivalent circuit of single phase transformer referred to both sides by developing computer programs.	1
CO 5	**PO 1**	Outline of materials and brief description of formation of semi-conductor devices by using basic fundamentals of science and engineering.	3
	PO 2	Recognize (knowledge) the working and characteristics of diode and understand application which is rectifier circuit using engineering knowledge, and types of rectifiers.	3
CO 6	**PO 1**	List out various transistor configurations and discuss their working using principles of science and mathematical principles.	3
	PO 2	Explain the concept of biasing and load lines and their applicability in solving problems and working of transistors as switch and amplifier.	3

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

0 - $0 \leq$ 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	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 5	3	1	-	-	-	-	-	-	-	-	-		-	-	-
CO 6	3	1	-	-	-	-	-	-	-	-	-		-	-	-
TOTAL	**18**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**
AVERAGE	**3**	**0.5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.3**	**0**	**0**

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**ELECTRICCIRCUITS,ELECTROMAGNETISM AND INSTRUMENTS**
	Electrical Circuits: Basic definitions, types of elements, Ohm's Law, resistive networks, inductive networks, capacitive networks, Kirchhoff's Laws, series, parallel circuits and star delta transformations, simple problems, Faradays law of electromagnetic induction; Instruments: Basic principles of indicating instruments, permanent magnet moving coil and moving iron instruments.
MODULE II	**DC MACHINES**
	DC Machines: Principle of operation of DC generator, EMF equation, principle of operation of DC motors, torque equation, types of DC machines, applications, three point starter.
MODULE III	**ALTERNATING QUANTITIES AND AC MACHINES**
	Alternating Quantities: Sinusoidal AC voltage, average and RMS values, form and peak factor, concept of three phase alternating quantity; Transformer: Principle of operation, EMF equation, losses, efficiency and regulation. Three Phase Induction Motor: Principle of operation, slip, slip torque characteristics, efficiency, applications; Alternator: Principle of operation, EMF Equation, efficiency, regulation by synchronous impedance method.
MODULE IV	**SEMICONDUCTOR DIODE AND APPLICATIONS**
	Semiconductor Diode: P-N Junction diode, symbol, V-I characteristics, half wave rectifier, full wave rectifier, bridge rectifier and filters, diode as a switch, Zener diode as a voltage regulator.
MODULE V	**BIPOLAR JUNCTION TRANSISTOR AND APPLICATIONS**
	Bipolar junction: Working principle of transistors, DC characteristics, CE, CB, CC configurations, biasing, load line, applications.

TEXTBOOKS

1. A Chakrabarti, "Circuit Theory", Dhanpat Rai Publications, 6thEdition,2004.
2. K S Suresh Kumar, "Electric Circuit Analysis", Pearson Education, 1stEdition,2013.
3. WillianmHayt, Jack E Kemmerly S M Durbin, "Engineering Circuit Analysis", Tata McGraw Hill, 7thEdition,2010.
4. J P J Millman, C CHalkias, SatyabrataJit, "Millmans Electronic Devices and Circuits", Tata McGraw Hill, 2ndEdition,1998.
5. R L Boylestad, Louis Nashelsky, "Electronic Devices and Circuits", PEI / PHI, 9th Edition, 2006.
6. V K Mehta, Rohit Mehta, —Principles of electrical engineering, S CHAND, 1st Edition, 2003.

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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/aeronautal-engineering-autonomous/basics -of-electrical-and-electronics-engineering

XIX COURSE PLAN:

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

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

16	Principle of operation for Single Phase Transformers	CO 4	T1-13.1 to 13.3
17	Construction and EMF equation for Single Phase Transformers	CO 4	T1-13.5 to 13.6
18	Types of transformers and turns ratio	CO 4	T1-13.6 to 13.7
19	Operation of transformer under no load	CO 4	T1-13.7 to 13.9
20	Operation of transformer under on load	CO 4	T1-13.8
21	Equivalent circuit for Transformers	CO 4	T1-17.1 to 17.2
21	Phasor diagrams of transformer	CO 4	T1-17.3 to 17.4
22	Losses of Transformers	CO 4	T1-17.6 to 17.7
23	Efficiency of Transformers	CO 4	T1-13.11
24	Regulation for Transformers	CO 4	T1-13.12
25	Three Phase Induction motor: Principle of operation	CO 4	T1-13.13
26	slip, slip -torque characteristics	CO 4	T1-13.14
27	Alternators: Introduction, principle of operation	CO 4	T1-13.19
28	Constructional features	CO 4	T1-13.20
29	Understand the concept of P-N junction diode, symbol	CO 5	T1-13.8
30	Learn the V-I characteristics of P-N junction diode	CO 5	T1-17.1 to 17.2
31	Discuss the concept of half wave rectifier and full wave rectifier	CO 5	T1-17.3 to 17.4
32	Understand the bridge rectifiers and filters	CO 5	T1-17.6 to 17.7
33	Discuss the concept of diode as a switch, Zener diode as a voltage regulator	CO 5	T1-13.11
34	Know the concept of Transistors and Understand the configurations	CO 6	T1-13.12
35	Understand the DC characteristics of transistor	CO 6	T1-13.13
36	Understand the biasing and load line analysis.	CO 6	T1-13.13
37	Discuss how transistor acts as an amplifier.	CO 6	T1-13.13
PROBLEM SOLVING/ CASE STUDIES			
38	Numerical Examples on electrical quantities, Ohm's law, KCL, KVL	CO 1	T1-5.8 to 5.9
39	Numerical Examples on series, parallel elements and star to delta transformation and mesh analysis	CO 1	T1-5.5 to 5.8
40	Numerical Examples on nodal analysis and alternating quantities	CO 1	T1-6.8 to 6.9
41	Numerical Examples on Superposition theorem	CO 1	T1-6.2 to 6.3
42	Numerical Examples on reciprocity and maximum power transfer theorems	CO 1	R2-7.1 to 7.2

43	Numerical Examples on Thevenin's and Norton's theorems	CO 1	T1-13.1 to 13.3
44	Numerical Examples on EMF equation and types of DC generators	CO 3	T1-13.6 to 13.7
45	Numerical Examples on torque equation of DC motor	CO 3	T1-13.1 to 13.3
46	Numerical Examples on types of DC motors	CO 3	T1-13.13
47	Numerical Examples on EMF equation and equivalent circuit of 1 phase transformer	CO 4	T1-13.16 to 13.18
48	Numerical Examples on, efficiency for Transformers	CO 4	T1-13.14
49	Numerical Examples on, regulation for Transformers	CO 4	T1-13.16 to 13.18
50	Numerical Examples on EMF of Alternators	CO 4	T1-13.19
51	Numerical Examples on regulation of Alternators	CO 4	T1-13.20
52	Numerical Examples on Rectifiers	CO 5	T1-13.19
53	Numerical Examples on transistors	CO 6	T1-13.19
DISCUSSION OF DEFINITION AND TERMINOLOGY			
54	Definitions on basics of electrical circuits and electrical instruments	CO 1	T1-5.1 to 5.3
55	Definitions on DC machines	CO 2	T1-6.1 to 6.3
56	Definitions on single phase AC circuits and AC machines	CO 3	R2-7.1 to 7.2
57	Definitions on semiconductor diode and applications	CO 5	T1-13.1 to 13.3
58	Definitions on bipolar junction transistor and applications	CO 6	T1-13.11
DISCUSSION OF QUESTION BANK			
59	Questions from electrical circuits and electrical instruments	CO 1	T1-5.1 to 5.3
60	Questions from DC machines	CO 2	T1-6.1 to 6.3
61	Questions from single phase AC circuits and AC machines	CO 3	R2-7.1 to 7.2
62	Questions from semiconductor diode and applications	CO 5	T1-13.1 to 13.3
63	Questions from bipolar junction transistor and applications	CO 6	T1-13.11

Signature of Course Coordinator **HOD,AE**

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

Course Title	**THEORY OF STRUCTURES**				
Course Code	AAE002				
Program	B.Tech				
Semester	III	AE			
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	3	2
Course Coordinator	Mr S Devaraj, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME002	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
Theory of 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						

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

VI COURSE OBJECTIVES:

The students will try to learn:

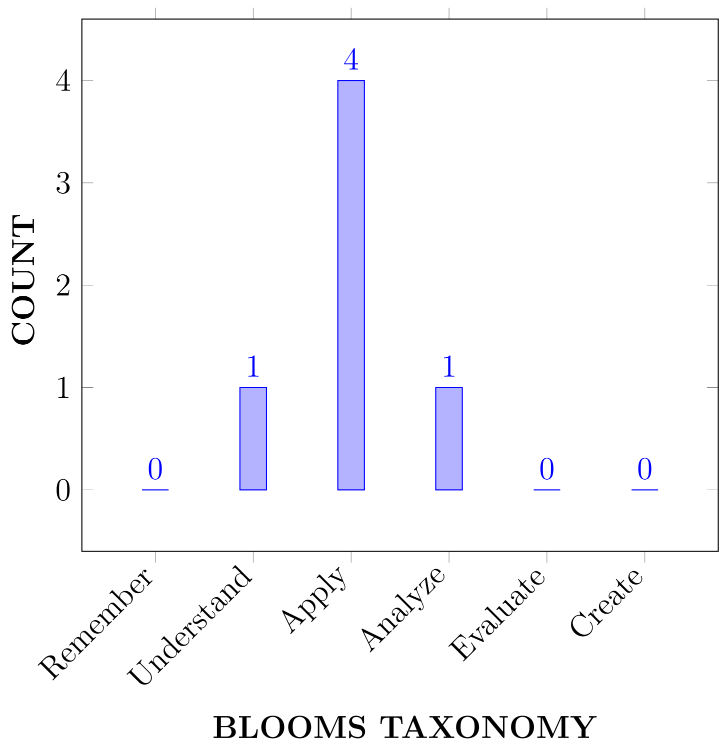
I	The concepts of mechanics of deformable solids and their constitutive relations (including stress – strain relations), principal stresses and strains and resilience produced under various loading conditions for determining the strength of aircraft structures.
II	The methods of determining shear force - 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	**Choose** basics of elasticity for determining the mechanical properties in designing aircraft structural components	Understand
CO 2	**Analyze** the effects of various loading conditions on symmetric and un symmetric beams for determining the flexural and shear stresses.	Apply
CO 3	**Make use** of different methods such as forto find deflections under different loading conditions.	Apply
CO 4	**Evaluate** the buckling of a column using Eigen values and Eigen vectors to understand the required strength of a column.	Apply
CO 5	**Differentiate** the different alternative methods available for determining the behaviour of trusses.	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

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

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.6	30	-	-	-	-	-	-	-	-	-	-	-	25	-
CO 2	66.6	50	-	-	-	-	-	-	-	-	-	-	-	50	-
CO 3	66.6	50	-	-	-	-	-	-	-	-	-	-	-	25	-
CO 4	66.6	30	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.6	30	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.6	30	-	-	-	-	-	-	-	-	-	-	-	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	1	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	1	-	-	-	-	-	-	-	-	-	-	-	1	-
TOTAL	18	8	-	-	-	-	-	-	-	-	-	-	-	5	-

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:

UNIT-I	**INTRODUCTION**
	Mechanical properties of materials; Stresses and strains; Hooke‘s law, elastic constant, relation between modulii, working stress, factor of safety, poisons ratio ; bars of varying cross section; Thermal stresses. Torsion of solid and hollow circular shafts and shear stress variations; Power transmission in shafts; Shear force and bending moment diagrams for different types of beams with various loads.
UNIT-II	**STRESSES IN BEAMS**
	Bending stresses and Shear stress variation in beams of symmetric and un-symmetric sections; Beams of uniform strength; Flexural stresses: Bending equations, calculation of bending stresses for different sections of beams like I, L, T, C, angle section.
INIT-III	**BEAMS AND COLUMNS**
	Deflection of beams by Double integration method, Macaulay‘s method, moment area method, conjugate beam method; Principle of superposition. Columns, types of columns, Euler‘s formula instability of columns, Rakine‘s and Jonson‘s formula, Eigen values and Eigen modes, concept of beam-column
UNIT-IV	**REDUNDANT STRUCTURES**
	Trusses, perfect frames, analysis of trusses; Determinate and indeterminate structures, order of redundancy; Redundant analysis, analysis of determinate structures, area movement method, Clayperons method, slope deflection method, moment distribution method.

UNIT-V	**THEORY OF ELASTISITY**
	Equilibrium and compatibility conditions and constitute relations for elastic solid and plane: generalized plane strain cases Airy's stress function Stress on inclined planes, stress transformations determination of principal stresses and strains by analytical method and graphical method - Mohr's circles and its constructions.

TEXTBOOKS

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

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1. Dym, C. L, Shames, I. H, —Solid Mechanics, McGraw Hill, Kogakusha, Tokyo, 7th Edition, 2007.
2. Stephen Timoshenko, —Strength of Materials, Vol I & II, CBS Publishers and Distributors, 3rd Edition, 2004.
3. R. K. Rajput, —Strength of Materials, S. Chand and Co., 1st Edition, 1999.

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	References
	OBE DISCUSSION		
1	Course Objectives, Course Outcomes, Program Objectives and Program Outcomes		
	CONTENT DELIVERY (THEORY)		
1	Introduction to Strength of Materials. Basic principles of mechanics.	CO 1	R1: 1.1
2	Simple stresses and strains- Types of stress and strains -	CO 1	T1: 1.1 to 1.6 R1: 2.1,2.4
3	Stress-strain diagram for mild steel – Working stress – Factor of safety.	CO 1	T1: 1.6 R1: 2.5
4	Mechanical properties of materials and Hook's Law safety.	CO 1	T1: 1.6 R1: 2.5
5	Lateral strain, Poisson's ratio and volumetric strain – Elastic moduli and the relationship between them.	CO 1	T1: 1.7 R1: 3.1,3.13
6	Bars of uniform and varying sections – Numerical examples	CO 1	T1: 1.10 R1: 2.7

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

22	Derivation of S.F and B.M diagrams for simply supported beam (SSB) subjected to combination of point load uniformly distributed load.	CO 2	T1: 6.7, 6.8 R1: 9.5
23	Derivation of S.F and B.M diagrams for simply supported beam (SSB) subjected to uniformly varying load (UVL)over its entire span and half span conditions.	CO 2	T1: 6.7, 6.8 R1: 9.5
24	Derivation of S.F and B.M diagrams for simply supported beam (SSB) subjected to combination all types of loads.	CO 2	T1: 6.7, 6.8 R1: 9.5
25	Derivation of S.F and B.M diagrams for over hanged beam (SSB) subjected to combination all types of loads.	CO 2	T1: 6.7, 6.8 R1: 9.5
26	Determination of point of contraflexture for the beam carrying different loads on it.	CO 2	T1: 6.7, 6.8 R1: 9.5
27	Theory of simple bending. Assumptions – Derivation of bending equation: M/I= f/y = E/R	CO 3	T1:7.2, 7.3, 7.4 R1: 10.2 to 10.5
28	Assumptions – Derivation of bending equation: M/I= f/y = E/R	CO 3	T1:7.2, 7.3, 7.4 R1: 10.2 to 10.5
29	Neutral axis – Determination of bending stresses.	CO 3	T1:7.5 R1: 10.6
30	Section modulus of rectangular (Solid and Hollow) sections.	CO 3	T1:7.7, 7.8 R1: 10.7
31	Section modulus of circular sections (Solid and Hollow) sections.	CO 3	T1:7.7, 7.8 R1: 10.7
32	Section modulus of I,T, Angle and Channel sections	CO 3	T1:7.7, 7.8 R1: 10.7
33	Derivation of formula for shear stress	CO 4	T1:8.1 to 8.3 R1: 11.3 to 11.6
34	Distribution of Shear stress across various beam sections like rectangular, circular, triangular sections.	CO 4	T1:8.1 to 8.3 R1: 11.3 to 11.6
35	Distribution of Shear stress across various beam sections like I, T and angle sections.	CO 4	T1:8.1 to 8.3 R1: 11.3 to 11.6
36	Double integration method for finding the slopes and deflection for different types of beams under different loading conditions.	CO 5	T1:8.1 to 8.3 R1: 11.3 to 11.6

37	Macaulay's method for finding the slopes and deflection for different types of beams under different loading conditions.	CO 5	T1:8.1 to 8.3 R1: 11.3 to 11.6
38	Introduction to theory of pure torsion and assumptions made in pure torsion – Derivation of torsion equation.	CO 6	T1:16.2 R1: 21.2 to 21.4
39	Derivation of torsion equation.	CO 6	T1:16.2 R1: 21.2 to 21.4
40	Torsional moment and polar section modulus.	CO 6	T1:16.3 R1: 21.5, 21.6
41	Torsional moment and polar section modulus. Derive equation for power transmitted by shafts and its efficiency.	CO 6	T1:16.3 R1: 21.5, 21.6
42	Principal stresses and strains- Stresses induced due to uniaxial stress-Stresses induced due to state of simple/pure shear.	CO 6	T1:4.1, 4.2 R1: 4.7
43	Stresses due to biaxial stresses - Stresses due to biaxial stresses along with shear stress.	CO 6	R1: 4.2, 4.3
44	Construction of Mohr's circle for computing the stresses.	CO 6	R1: 4.7
PROBLEM SOLVING/ CASE STUDIES			
1	A tensile test was conducted on a mild steel bar. The following data was obtained from the test: Diameter of steel bar = 3 cm ; Gauge length of the bar = 20 cm; Load at elastic limit = 250 kN; Extension at load of 150 kN = 0.21 mm; Maximum load = 380kN; Total extension = 60 mm; Diameter of rod at failure = 2.25 cm; Determine: (a) Young's modulus (b) stress at elastic limit (c)percentage elongation (d)percentage decrease in area	CO 1	R2:2.5
2	A steel rod of 3cm diameter and 5m long is connected to two grips and the rod is maintained at a temperature of 95°C. Determine the stress and pull exerted when the temperature falls to 30°C, if (i) the ends do not yield, and (ii) the ends yield by 0.12cm. Take E=2x10^5 MN/m^2 and α = 12x10^{-6}/°C	CO 1	R2:2.8
3	Determine the Poisson's ratio and bulk modulus of a material, for which Young's modulus is 1.2x10^5 N/mm^2 and modulus of rigidity is 4.5x10^4 N/mm^2	CO 1	R2:2.15
4	Analyse the cantilever beam of length 4m carries point loads of 1kN, 2kN and 3kN at 1, 2 and 4m from the fixed end. Draw the S.F and B.M diagrams for the cantilever.	CO 2	R2:4.1
5	Analyse the beam of length 10m is simply supported and carries point loads of 5kN each at a distance of 3m and 7m from the left end and also a uniformly distributed load of 1kN/m between the point loads. Draw the S.F and B.M diagrams for the beam.	CO 2	R2:4.2

6	Analyse the simply supported beam of length 10 m is carrying a uniformly distributed load of 2kN/m for 4m from the right end. Draw the S.F and B.M diagrams for the beam.	CO 2	R2:4.13
7	A square beam 20mm x 20mm in section and 2m long is supported at the ends. The beam fails when a point load of 400N is applied at the centre of the beam. What uniformly distributed load per meter length will break a cantilever of same material 40mm wide, 60mm deep and 3m long?	CO 3	R2:5.5
8	A circular log of wood is used as a beam. If the diameter of the log is 200 mm, find the moment of resistance of the section. Permissible stresses are 10 N/mm^2 in tension and 18 N/mm^2 in compression.	CO 3	R2:5.12
9	The maximum shear stress in a beam of circular section of diameter 150mm is 5.28 N/mm^2. Find the shear force to which the beam is subjected.	CO 4	R2:6.10
10	A steel cantilever beam of 6m long carries 2 point loads 15KN at the free end and 25KN at the distance of 2.5m from the free end. To determine the slope at free end & also deflection at free end $I = 1.3 * 10^8 mm^4$. $E = 2 * 10^5 N/mm^2$	CO 5	R2:7.3
11	A beam having uniform section is 14m long and simple supported at its end and caries a point load of 12KN and 8KN at two points 3m and 4m from the two ends respectively. Take $I = 160 * 10^3 mm^4$ and E=210KN/mm^4 and calculate deflection of the beam at point under the two loads by using macaulays method.	CO 5	R2:7.5
12	A cantilever 2m long is of rectangular section 100mm wide and 200mm deep. it carries a UDL of 2KN/m length for a length of 1.25m from fixed end a point load of 0.8KN at its free end. Find the deflection at the free end. Take E=10GN/m^2	CO 5	R2:7.9
13	A hollow circular shaft, of outside diameter 50 mm and inside diameter 36mm, is made of steel, for which the permissible stress in shear is 90 MPa and G = 85 GPa. Find the maximum torque that such a shaft can carry and the angle of twist per metre length.	CO 6	R2:9.11
14	At a point in a strained material, the principal stresses are 140 N/mm^2 (tensile) and 60N/mm^2 (compressive). Identify the resultant stress in magnitude and direction on a plane inclined at 45^0 to the axis of the major principal stress. What is the maximum intensity of shear stress in the material at the point?	CO 6	R2:9.15
15	A piece of material is subjected to tensile stresses of 70N/ mm^2 and 50N/mm^2 at right angles to each other. Identify the stresses on a plane the normal of which makes an angle 35^0 with the 70N/ mm^2 stress.	CO 6	R2:9.17

DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Definitions of stress, strain, elastic modulis, poissons ratio, factor of safety, working stress, ultimate stress and statement of Hooks law	CO 1	R4:2.1
2	Definitions of shear force, bending moment, and types of beams and loads	CO 2	R5:3.6
3	Definition of simple bending, assumptions, equation of bending moment, pure bending and shear stress.	CO 3, CO 4	R6:4.5
4	Definition of shear stress, equation of shear stress, section modulus and radius of gyration	CO 5	R7:2.5
5	Definition of plane stress, strain conditions, types of failures, torsion, angle of twist, torsional equation and rigidity modulus	CO 6	R8:2.6
DISCUSSION OF QUESTION BANK			
1	UNIT I	CO 1	R4:2.1
2	UNIT II	CO 2	T4:7.3
3	UNIT III	CO 3, CO 4	R4:5.1
4	UNIT IV	CO 5	T1:7.5
5	UNIT 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	MECHANICS OF SOLIDS LABORATORY				
Course Code	AAE101				
Program	B.Tech				
Semester	III	AE			
Course Type	Foundation				
Regulation	R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Dr. Y B Sudhir Sastry, 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:

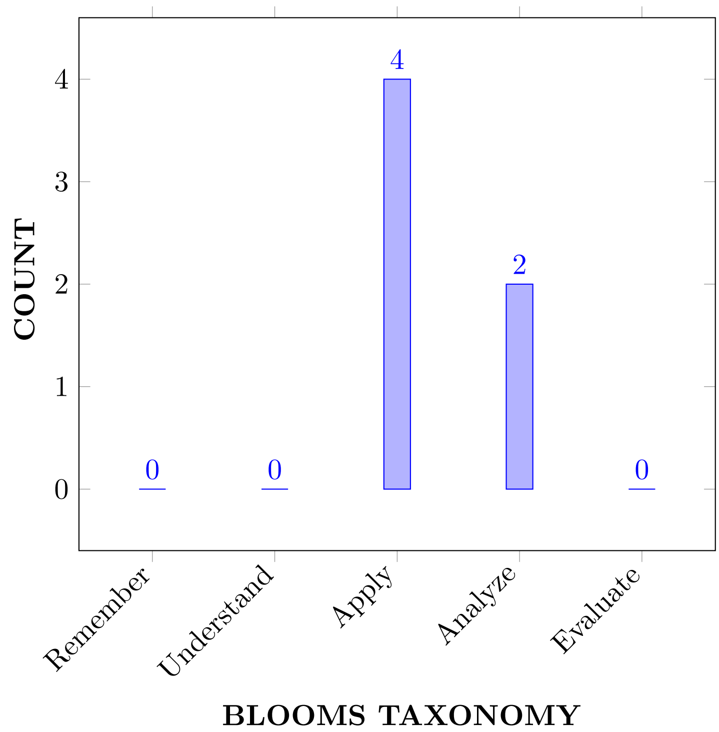
I	Learn the basic knowledge on the mechanical behaviour of materials like aluminium, mild steel, and cast iron.
II	Adopt with the experimental methods to determine the mechanical properties of materials.
III	Illustrate the crippling behaviour of different columns using Euler's and Rankine's theory.
IV	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	PROGRAM OUTCOMES					PSO'S
OUTCOMES	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 SSB AND CANTILEVER BEAM**
	Determine the Young‘s modulus of the given material with the help of deflection of SSB and cantilever beam.
WEEK XI	**REVIEW - I**
	Spare session for additional repetitions and review.
WEEK XII	**REVIEW - II**
	Spare session for additional repetitions and review.
WEEK XIII	**REVIEW - I**
	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 SSB and cantilever 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**
Dr. Y B Sudhir Sastry, Professor

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

COURSE DESCRIPTION

Department	AERONAUTICAL ENGINEERING				
Course Title	Airplane Performance				
Course Code	AAE011				
Program	B.Tech				
Semester	V				
Course Type	Core				
Regulation	R-16				
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
B.Tech	AAE003	III	Fluid Mechanics and Hydraulics

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
Airplane Performance	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
33.3%	Understand
50%	Apply
16.6%	Analyze

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

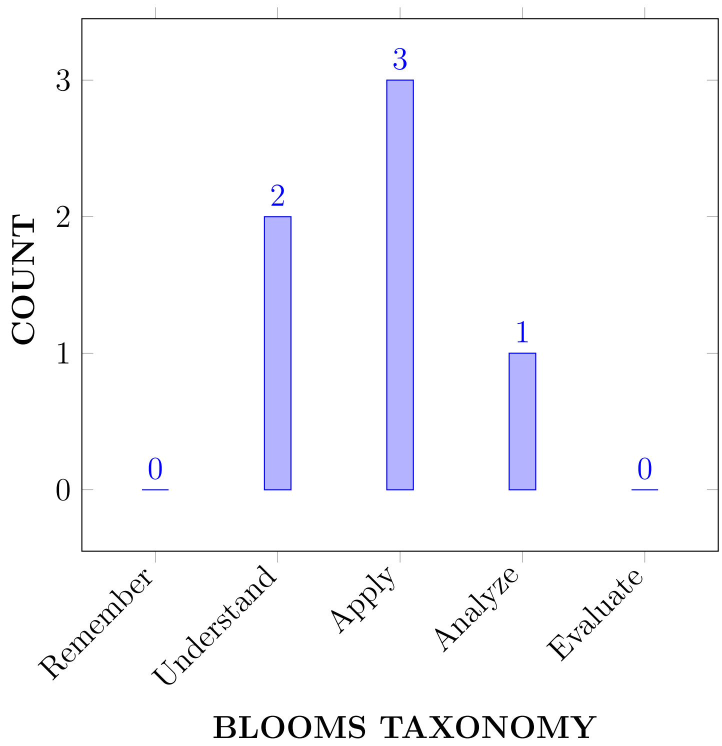
I	The fundamental principles of aerodynamics and propulsion for aircraft performance in classical flying stages.
II	The different regimes of aircraft and performance requirements at various atmospheric conditions.
III	The mathematical models for various types of maneuvers, safety requirements during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

VII COURSE OUTCOMES:

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

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

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	1	Quiz
PSO 3	Successful career and Entrepreneurship:Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies	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 to understand the basics of aircraft performance, determining reactions and resultants of forces using the using principles of mathematics, science, and engineering fundamentals.	2
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems related to aircraft performance under various forces in reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3
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 2	Identify, formulate, review research literature, and analyze complex engineering problems related to aircraft performance under various forces in reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3
	PSO 3	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	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
	PO 3	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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
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
	PO 4	Interpret the force system of the aircraft and the development of equations of motion as individual and team work.	2
	PSO 3	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	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 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 3	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
	PO 2	Identify, formulate, review research literature, and analyze complex engineering problems related to aircraft performance under various forces in reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3
	PO 3	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
	PO 4	Interpret the force system of the aircraft and the development of equations of motion as individual and team work.	2
	PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	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	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 3	2	2	1	-	-	-	-	-	-	-	-	-	-	-	1
CO 4	2	2	-	3	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	1	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 6	1	2	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	66.7	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	66.7	66.7	-	-	-	-	-	-	-	-	-	-	-	-	50
CO 3	66.7	66.7	50	-	-	-	-	-	-	-	-	-	-	-	18
CO 4	66.7	66.7	-	80	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.7	66.7	-	-	-	-	-	-	-	-	-	-	-	-	50
CO 6	40	66.7	66.7	66.7	-	-	-	-	-	-	-	-	-	66.7	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

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

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

TEXT BOOKS

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

Reference BOOKS

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

WEB REFERENCES:

https://akanksha.iare.ac.in/index?route=course/detailscourse$_{i}d = 105$

COURSE WEB PAGE:

https://akanksha.iare.ac.in/index?route=course/detailscourse$_{i}d = 105$

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 A Rathan Babu, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

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

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

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

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

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

Signature of Course Coordinator **HOD,**

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

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**AEROSPACE STRUCTURES LABORATORY**				
Course Code	AAE104				
Program	B.Tech				
Semester	IV	AE			
Course Type	Laboratory				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Shravani Madhurakavi, Assistant Professor				

I COURSE OVERVIEW:

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

II COURSE PRE-REQUISITES:

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

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

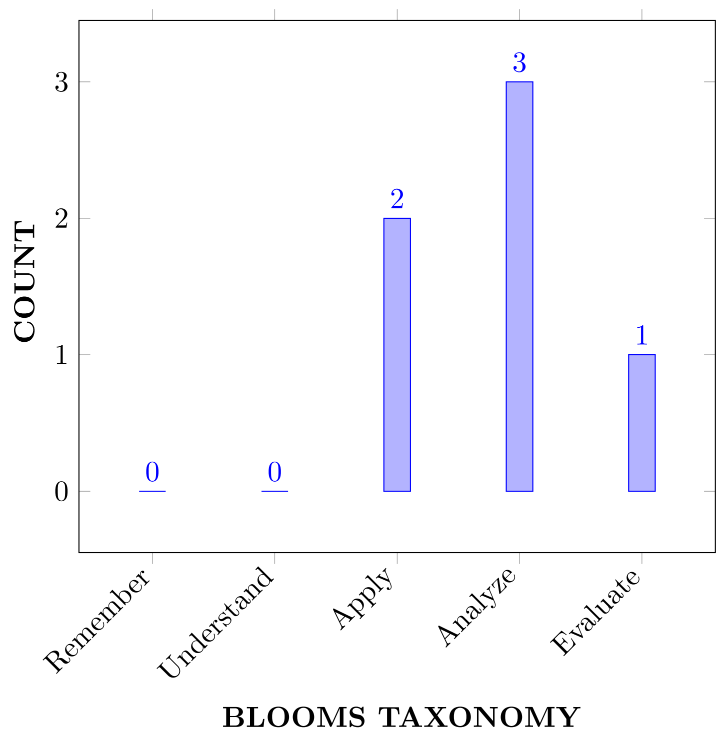
I	The basic knowledge on the mechanical behavior of materials such as aluminum, mild steel, and cast iron for determining its behavior under different load conditions .
II	The identification of crack/flaws using Non Destructive Testing (NDT) methods for choosing proper materials in engineering applications .
III	Understand the concept of shear centre for open and Closed section 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.	Analyze
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.	Analyze
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.	Evaluate
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.	Aply
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	Identify (knowledge) the basic properties of various engineering materials, to a considerable extent appreciate (understanding) their importance and applicability (apply) in solving (complex) structural engineering problems by applying the principles of mathematics, science.	3
	PO 2	Understand the (given **problem statement**) and material properties for (provided **information and data**) in reaching substantiated conclusions by the interpretation of results	3

	PSO 3	Apply (**knowledge**) properties of various types matrials and stress-strain curves (apply) for solving design problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 2	PO 1	Apply the basic equations of science for various phenomena of structural systems and use **mathematical principles** for deriving (complex) structural engineering equations by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals** of structural mechanics.	3
	PO 3	Understand the given **problem statement** and formulate (complex) buckling phenomena and system for deriving various governing equations of structural 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 structural 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 3	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** to determine shear center for a given beam geometry, to avoid torsion under the applied load and behaviour of a beam deflection in out of plane	2
	PO 5	Using first **principles of Sciences and Engineering fundamentals** understand the concept of shear center and its importance in design of aerospace structures.	2
	PSO 3	Extend the focus to **understand the innovative and dynamic challenges** involves in evaluation of shear center and unsymmetrical beam deflection.	1
CO 4	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** to determine the material properties to design a structure with maximize strength and determine the shear stresses in tension field beams	2
	PO 5	Using first **principles of Sciences and Engineering fundamentals** understand the concept of engineering materials to optimze the strength and weight of a given structure and failure of tension field beams.	2
	PSO 3	Extend the focus to **understand the innovative and dynamic challenges** involves in evaluation of light weight materials involved in construction of aircraft structures and stresses in tension field beams.	1
CO 5	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** for determining flaws in a given materials.	2

	PO 5	Using first **principles of Sciences and Engineering fundamentals** understand the concept flaw detections and crack growths under given loading conditions.	2
	PSO 3	Extend the focus to **understand the innovative and dynamic challenges** involves in flaw detections techniques.	1
CO 6	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** for determining the response of vibrating machines such as acceleration, velocity and displacement etc for designing the new equipment's under desirable conditions	2
	PO 5	Using first **principles of Sciences and Engineering fundamentals** to understand the concept of vibration test equipment for avoiding failures due to vibrations like fatigue	2
	PSO 3	Extend the focus to **understand the innovative and dynamic challenges** involves in evaluation of vibration testing equipment design.	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 5	PSO 3
CO 1	3	3	-	-	3
CO 2	3	-	2	2	3
CO 3	2	-	-	2	1
CO 4	2	-	-	2	1
CO 5	2	-	-	2	1
CO 6	2	-	-	2	1

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	**UNSYMMETRICAL BEAM BENDING TEST**
	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.

TEXT BOOKS

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

REFERENCE BOOKS:

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

XV COURSE PLAN:

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

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

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**
Shravani Madhurakavi,
Assistant Professor

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

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**AIRCRAFT MATERIALS AND PRODUCTION LABORATORY**				
Course Code	AAE105				
Program	B.Tech				
Semester	IV	AE			
Course Type	CORE				
Regulation	R 16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Mr.S.Devaraj, 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	AME101	I	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.

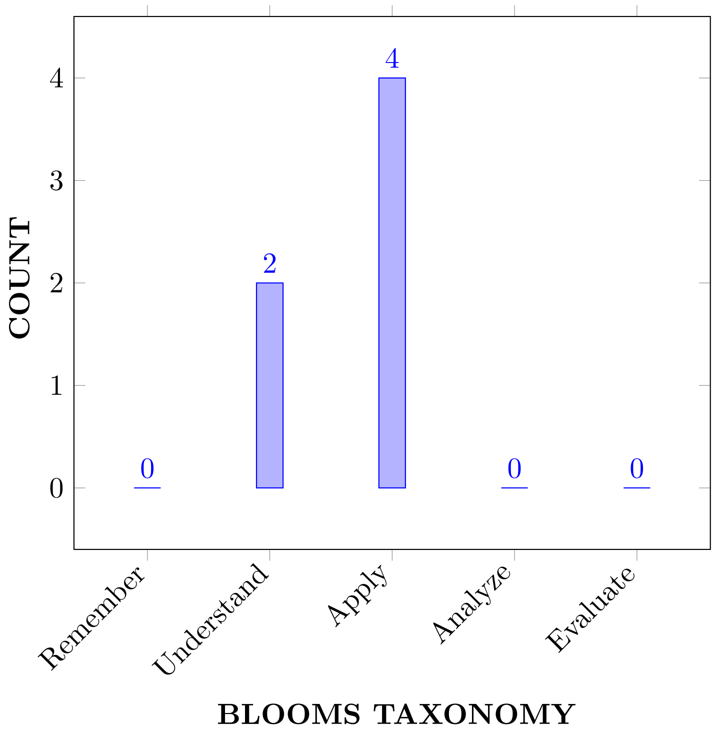
VII COURSE OUTCOMES:

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**
	Introduction- lathe machine, plain turning, Step turning and grooving, Taper turning-compound rest/offset method and Drilling using lathe, External threading-Single start
WEEK IV	**SHAPING and SLOTTING**
	Shaping-V-Block and Slotting-Keyways.
WEEK V	**MILLING and GRINDING**
	Grinding-Cylindrical /Surface/Tool and cutter. Milling-Polygon /Spur gear, Gear hobbing-Helical gear.
WEEK VI	**DRILLING**
	Drilling, reaming, counter boring, Counter sinking and Taping
WEEK VII	**CNC MACHINING**
	Basic operations, Introduction to CNC programming.
WEEK VIII	**WELDING PROCESS-I**
	Gas Welding, Brazing and Soldering.
WEEK IX	**WELDING PROCESS-II**
	Arc welding and Spot welding
WEEK X	**BASIC CASTING**
	Preparation of casting with simple patterns.
WEEK XI	**RIVETING ALUMINIUM SHEETS**
	Solid and Blind Rivets on aluminium sheets.

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 metal joining technique with the help of rivets.	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.S.Devaraj, Assistant Professor

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COURSE DESCRIPTION

Course Title	**LOWSPEED AERODYNAMICS**				
Course Code	AAE004				
Program	B.Tech				
Semester	IV	AE			
Course Type	Core				
Regulation	R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Dr. Maruthupandiyan K, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAE003	III	Fluid Mechanics and Hydraulics

II COURSE OVERVIEW:

Lowspeed 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). 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
20%	Remember
30%	Understand
30%	Apply
20%	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	The fundamental knowledge on basics of aerodynamics and aerodynamic characteristics of wings, airfoils.

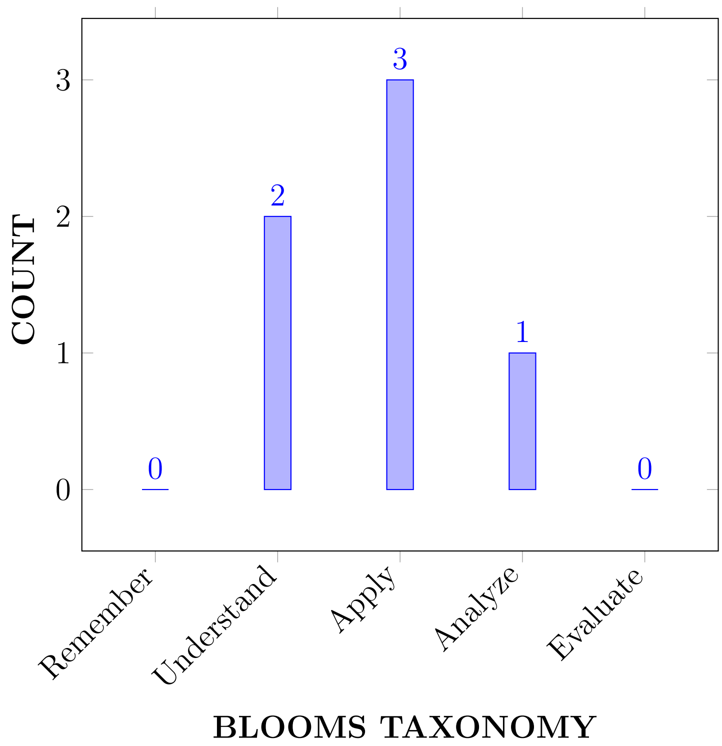
II	The mathematical model for lift and drag coefficient of finite wing and wing of infinite aspect ratio.
III	The flow over non-lifting bodies from method of singularities and investigate the interference effect
IV	The effect of viscosity and boundary layer growth over various shaped geometry and its control.

VII COURSE OUTCOMES:

After successful completion of the course, students 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** method of singularity for mathematically modeling the flow over non-lifting bodies.. Apply	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
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/SEE/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	CIE/SEE/AAT
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/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/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/ 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** for **modelling** uniform flow over cylinder.	4
	PSO 1	**Conceptualize** method of singularities by **building** non-lifting, lifting flow over circular cylinder for **formulating and solving** flow over arbitrary bodies.	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 the provided**information and data** for **modelling** uniform flow over a thin airfoil.	4
	PO 3	**Identify** lift characteristics of wing of infinite aspect ratio from classical thin airfoil for **investigating** the physical parameters that govern fluid systems in **designing** prototypes devices and **evaluate outcomes** of design process	4
	PSO 1	**Conceptualize** the thin airfoil theory by **building** uniform flow over thin airfoil for **formulating and solving** flow over wing of infinite aspect ratio	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
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
	PO 2	Understand the given **problem statement** and **formulate** the lift characteristics of wing of finite aspect ratio from the provided**information and data** for **modelling** uniform flow over a finite wing	4
	PSO 1	**Conceptualize** Prandtl's Liftingline theory by **building** uniform flow over finite wing for **formulating and solving** flow over wing of finite aspect ratio	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	Understand the given **problem statement** and **formulate** the effect of twist and taper from **information and data** for **modelling** a finite wings with sweep and twist	4
	PO 3	**Identify** the effect of wing twist, wing taper and wing sweep for **investigating** the physical parameters that govern the **designing** of finite wing and **evaluate outcomes** of design process	4
	PSO 1	**Conceptualize** the effect of twist and sweep by **building** finite wing with taper for **formulating and solving** flow over wing of finite aspect ratio with different geometrical modifications	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	Understand the given **problem statement** and **formulate** the effect of properrler slip stream on wing and tail unit from **information and data** for **modelling** a finite wings with propellor	4
	PO 4	**Understand**the **engineering principle** of propeller slip stream to **idetify** their effect on tail unit **(awareness)** by **applying the system approach**	5
	PO 5	Using the **technical library resources** to understand the effect of propeller slipstream flow on the aerodynamic characteristics of wing and tail for designing desired equipment's	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 1	**Conceptualize** the effect of propeller slipstream on tail unit by **building** slipstream flow over wing and tail unit to **formulat and solve** their influence on overall aircraft performance.	3
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	**Identify** the zones of boundary layer to **formulate** the flow over flat plate from the provided (**Problem statment, information and data**)for **Interpreting** the characteristics of boundary layer	4
	PO 4	**Understand**the **engineering principle** of boundary layer formation over flat plate to **idetify** their effect on aerodynamic characteristics **(awareness)**of viscous flow over a solid body by **applying the system approach**	5
	PSO 1	**Conceptualize** the effect of viscous flow on a flat plate by **building** laminar and turbulet flow over flat plate to **formulat and solve** their influence on the aerodynamic characteristics	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	4	-	-	-	-	-	-	-	-		3	-	-
CO 5	3	4	-	5	1	-	-	-	-	-	-	4	3	-	-
CO 6	3	4	-	5	-	-	-	-	-	-	-	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	-	-	-	-	-	-	-	-	-	-	75	-	-
CO 2	100	40	40	-	-	-	-	-	-	-	-		75	-	-
CO 3	100	40		-	-	-	-	-	-	-	-	-	75	-	-
CO 4	100	40	40	-	-	-	-	-	-	-	-		75	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 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	-	45	100	-	-	-	-	-	-	50	75	-	-
CO 6	100	40	45	-	-	-	-	-	-	-	-	50	75	-	

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	2	-	-	-	-	-	-	-	-		2	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 4	3	2	2	-	-	-	-	-	-	-	-		3	-	-
CO 5	3	2	-	2	3	-	-	-	-	-	-	2	3	-	-
CO 6	3	2	2	-	-	-	-	-	-	-	-	2	3	-	-
TOTAL	18	12	6	2	3		-	-	-	-	-	4	18	-	-
AVERAGE	3	2	2	2	3		-	-	-	-	-	2	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 INTERFERENCE EFFECTS**
	Flow past non lifting bodies, method of singularities; Wing-body interference; Effect of propeller on wingsandbodies and tail unit; Flow over airplane as a whole
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	Objective of outcome based education		
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	CO 1	T2:119-130 R1:3.4
6	Sink,	CO 1	T2:119-130 R1:3.3
7	Doublet	CO 1	T2:119-130 R1:3.5
8	Vortex	CO 1	T2:119-130 R1:3.6
9	Non lifting and lifting flow over a cylinder	CO 1	T2:131-132 R1:3.7
10	Kutta-Joukowski theorem	CO 1	T2:167 R1:3.7
11	Aerofoil nomenclature	CO 2	T2: 192 R2:8.1
12	Aerodynamic characteristics,Centre of pressure,Aerodynamic centre	CO 2	T1:4.3 R2:8.1
13	Wing of infinite aspect ratio	CO 2	T1:1.6-4.9
14	CL-α - diagram for a wing of infinite aspect ratio	CO 2	T1:4.7
15	Generation of lift,Starting Vortex,Kutta's trailing edge condition	CO 2	T1:4.7
16	Thin aerofoil theory	CO 2	T1:4.5
17	Elements of panel method, High lift airfoils, High lift devices	CO 2	T1:4.7-4.10 R2:8.3

18	Vortex motions,Vortex line, Vortex tube,Vortex sheet	CO 3	T1:4.10
19	Circulation,Kelvin and Helmhotz theorem	CO 3	T1:5.2 R2:11.1
20	Biot-Savart's law applications	CO 3	T1:5.2
21	Rankine's vortex	CO 3	T1:5.3
22	Flow past finite wings	CO 3	T1:5.2 R2:10.1
23	Vortex model of the wing and bound vortices	CO 3	T1:5.3 R2:11.3
24	Induced drag	CO 3	T1:5.3 R2:11.3
25	Prandtl's lifting line theory	CO 3	T1:5.3 R2:11.3
26	Elliptic wing	CO 3	T1:5.3 R2:11.4
27	Influence of taper and twist applied to wings	CO 4	T1:5.4
28	Effect of sweep back wings	CO 4	T1:5.4
29	Delta wings	CO 4	T1:5.6
30	Primary and secondary vortex	CO 4	T1:5.6
31	Elements of lifting surface theory	CO 4	T1:5.5
32	Source Panel Vortex panel,Vortex lattice methods	CO 4	T1:5.4
33	Flow past non lifting bodies	CO 5	T1:5.4 R3:20.1
34	Method of singularities,Flow over airplane as a whole	CO5	T1:5.3 R3:20.1
35	Wing-body interference, Effect of propeller on wings and bodies and tail unit	CO5	T3:5.2 R3:20.2
36	Introduction to boundary layer	CO 6	T3:4.1
37	Laminar and turbulent and transition boundary layer	CO 6	T3:4.2-4.3
38	Boundary layer on flat plate	CO 6	T3:18.2
39	Displacement thickness, Momentum thickness	CO 6	T3:4.5
40	Energy thickness,Effect of curvature and Temperature boundary layer	CO 6	T3:4.5
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 propeller slip stream	CO 5	T2:6.5
11	Numerical problems related to nonlifting bodies	CO 5	T2:6.6
12	Numerical problems related to flow singularities	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	T2: T2:104-167
2	Thin airfoil theory, airfoil nomenclature	CO 2	T4:7.3
3	Prandtls lifting line theory, wing twist, taper and sweep	CO 3,4	R4:5.1
4	Wing-body interference,method of singularities,Effect of propeller on wings	CO 5	T1:7.5
5	Definition of boundary layer and separation, Bluff body and Streamlined body, Drag and lift	CO 6	T2: 7.1
DISCUSSION OF QUESTION BANK			
1	Stream function and Velocity Potential for elementary flows	CO 1	T2:104-167
2	Thin airfoil theory fundamentals	CO 2	R2:8.1-8.3
3	Flow over finite wing	CO 3,4	T1:5.2
4	Non lifting bodies	CO 5	R3:20.1
5	Boundary layer theory	CO 6	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	**THERMODYNAMICS**				
Course Code	AME003				
Program	B.Tech				
Semester	IV				
Course Type	CORE				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4		
Course Coordinator	Dr. P Srinivasa Rao				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS002	I	Linear Algebra and Ordinary Differential Equations
B.Tech	AHS007	II	Applied 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
17%	Remember
50 %	Understand
33 %	Apply
0 %	Analyze

Continuous Internal Assessment (CI):
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:

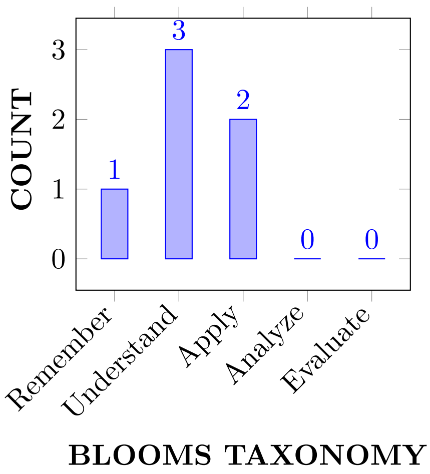
I	The concepts of thermodynamics, gas properties and the thermodynamic disorderness in the real time physical systems in heat engines, heat pumps and refrigerators for measure of their performance.
II	The characteristics of pure substances, mixtures, usage of steam tables, mollier' chart and psychometric 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	**Recall** the basic concepts of thermodynamic properties and working principles of energy conversions in physical systems by laws of thermodynamics.	Remember
CO 2	**Outline** the equivalence of two statements of second law of thermodynamics and the entropy concepts for typical engineering problems.	Understand
CO 3	**Interpret** the properties of pure substances and steam to emit relevant inlet and exit conditions of thermodynamic work bearing systems.	Understand
CO 4	**Apply** the significance of partial pressure and temperature to table the performance parameters of ideal gas mixtures.	Apply
CO 5	**Identify** the properties of air conditioning systems by practicing psychrometry chart and property tables.	Apply
CO 6	**Illustrate** the working of various air standard cycles and work output to get the performance characteristics.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	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
	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	Show the significance of partial pressure and temperature using **fundamental engineering and science** to table the performance parameters of gaseous mixtures **in mathematical form.**	3
	PO 2	**Identify, define, collect** the properties to discuss partial pressures to **model, solve problems and implement** in different areas of research by **validating the results.**	7
	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 performance of gaseous mixtures and their application on **real world problems.**	7
	PSO 3	Recall the properties of pure substances used in **thermal applications** to be applied in real life physical systems	2
CO 5	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 6	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.**	7

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	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 performance of characteristics of power cycles and their application on **real world problems.**	7
	PSO 3	Demonstrate the performance characteristics of air standard cycels by using the **basic understanding of engineering science 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	7	7	-	-	-	-	-	-	-	-	-	-	-	2
CO 2	3	7	5	-	-	-	-	-	-	-	-	-	-	-	2
CO 3	3	5	7	-	-	-	-	-	-	-	-	-	-	-	2
CO 4	3	7	7	-	-	-	-	-	-	-	-	-	-	-	2
CO 5	3	7	7	-	-	-	-	-	-	-	-	-	-	-	2
CO 6	3	7	7	-	-	-	-	-	-	-	-	-	-	-	3

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 3	3	2	3	-	-	-	-	-	-	-	-	-	-	-	2
CO 4	3	3	2	-	-	-	-	-	-	-	-	-	-	-	2
CO 5	3	3	3	-	-	-	-	-	-	-	-	-	-	-	2
CO 6	3	3	2	-	-	-	-	-	-	-	-	-	-	-	3
TOTAL	18	17	15	-	-	-	-	-	-	-	-	-	-	-	13
AVERAGE	3	2.83	2.5	-	-	-	-	-	-	-	-	-	-	-	2.16

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, elementary treatment of the Third Law of thermodynamics.

MODULE III	**PURE SUBSTANCES**
	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, various thermodynamic processes and energy transfer, steam calorimeter. Perfect gas laws: Equation of state, specific and universal gas constants, throttling and free expansion processes, deviations from perfect gas model, Vander Waals equation of state.
MODULE IV	**MIXTURES OF PERFECT GASES**
	Mixtures of perfect gases: Mole fraction, mass friction, gravimetric and volumetric analysis, volume fraction, Dalton's law of partial pressure, Avogadro's laws of additive volumes, and partial pressure, equivalent gas constant, internal energy, enthalpy, specific heats and entropy of mixture of perfect gases; psychometric properties, dry bulb temperature, wet bulb temperature, dew point temperature, thermodynamic wet bulb temperature, specific humidity, relative humidity, saturated air, vapour pressure, degree of saturation, adiabatic saturation, Carrier's equation, Psychometric chart.
MODULE V	**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.

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.

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	CO 1	T1:1.1
3	Macroscopic and Microscopic viewpoints,Concept of Continuum, Thermodynamic Equilibrium	CO 1	T1:1.5 R2:1.3
4	State, Property, Process, Cycle, Reversibility, Quasi static Process, Irreversible Process, types-work and heat, point and path function	CO 1	T1:1.6 R2: 1.39
5	Causes of Irreversibility, Various flow and non-flow processes, energy in state and in transition	CO 1	T1:1.7
6	Zeroth law of thermodynamics, concept of quality of temperature, Principles of thermometry, reference points, constant volume gas thermometer, ideal gas scale	CO 1	T2:1.8, R2: 1.63
7	PMMI Joule's experiments, first law of thermodynamics, corollaries first law applied to a process	CO 1	T1:2.1, R2: 1.72
8	First law applied to a flow system, Steady Flow Energy Equation	CO 1	T1:2.3
9	Thermal Reservoir, Heat Engine, Heat pump, Parameters of performance	CO 2	T1:2.4, R2: 2.13
10	Second Law of thermodynamics, Kelvin Planck and Clausius statements and their equivalence, Corollaries	CO 2	T1:2.5
11	PMM of second kind, Carnot's principle, Carnot cycle and its specialties	CO 2	T1: 6.3, R2: 2.19
12	Thermodynamic scale of temperature, Clausius inequality, Entropy	CO 2	T1:6.7
13	Principle of Entropy increase, availability and irreversibility,	CO 2	T1:6.5
14	Thermodynamic potentials, Gibbs and Helmholtz functions	CO 2	T1:6.11
15	Maxwell relations, elementary treatment of the Third Law of thermodynamics	CO 2	T1:7.6, R2: 2.23
16	Pure substances: Phase transformations, T-S and H-S diagrams, P-V-T surfaces	CO 3	T1:8.8, R2: 2.26
17	Triple point at critical state properties during change of phase	CO 3	T1:11.2, R2:2.32
18	Dryness fraction, Mollier charts, various thermodynamic processes and energy transfer	CO 3	T1:13.2
19	Steam calorimeter, problems	CO 3	T1:9.4, R2: 3.2
20	Perfect gas laws: Equation of state, specific and universal gas constants	CO 4	T1: 10.11, R2: 3.31
21	Throttling and free expansion processes	CO 4	T1: 11.2
22	Deviations from perfect gas model, Vander Waals equation of state.	CO 4	T1:15.2
23	Mixtures of perfect gases: Mole fraction, mass friction	CO 5	T1:10.3
24	Gravimetric and volumetric analysis, volume fraction	CO 5	T1:10.3
25	Dalton's law of partial pressure, Avogadro's laws of additive volumes, and partial pressure	CO 5	T1:10.5

S.No	Topics to be covered	CO's	Reference T1: 4.1
26	Equivalent gas constant, internal energy, enthalpy, specific heats	CO 5	T1:10.6
27	Entropy of mixture of perfect gase	CO 5	T1:15, R2:8
28	Psychometric properties, dry bulb temperature, wet bulb temperature	CO 5	T1:15, R2:8
29	Dew point temperature, thermodynamic wet bulb temperature	CO 5	T1:15, R2:8
30	Specific humidity, relative humidity, saturated air, vapour pressure	CO 5	T1:13.8, R2:8.15
31	Degree of saturation, adiabatic saturation, Carrier's equation	CO 5	T1:13.8, R2:8.15
32	Psychometric chart, Problems	CO 5	T1:13.9
33	Power cycles: Otto cycle description and representation on P-V and T-S diagram	CO 6	T1:18.1
34	Diesel cycle description and representation on P-V and T-S diagram	CO 6	T1:18.4
35	Dual combustion cycle description and representation on P-V and T-S diagram	CO 6	T2: 16.4
36	Thermal efficiency, mean effective pressures on air standard basis	CO 6	T2:17.2
37	Comparison of cycles	CO 6	T2:17-4
38	Introduction to Brayton cycle	CO 6	T2:17.9
39	Introduction to Bell Coleman cycle	CO 6	T2: 17.13
40	Problems on power cycles	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 R3:2.4
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 R4:2.4
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 R4:2.4
9	Problems on mixture of perfect gases	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

S.No	Topics to be covered	CO's	Reference T1: 4.1
12	Problems on Specific humidity, relative humidity, saturated air, vapour pressure	CO 5	T1:1.5 R1:2.4
13	Compute the efficiency of brayton cycle	CO 6	T1:1.5 R1:2.4
14	Problems on entropy concepts	CO 6	T1:1.5 R1:2.4
15	Problems on availability and unavailability	CO 6	T1:1.5 R3:2.4
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, Equation of state, specific and universal gas constants, Phase transformations, T-S and H-S diagrams, P-V-T surfaces, steam calorimeter	CO 3, CO 4	T1:1.5 R1:2.4
4	Dry bulb temperature, wet bulb temperature, dew point temperature, thermodynamic wet bulb temperature, specific humidity, relative humidity, relative humidity, saturated air, vapour pressure, degree of saturation, adiabatic saturation	CO 5	T1:1.5 R1:2.4
5	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	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	CO 3, CO 4	R2:5.1
4	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 5	T1:7.5
5	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 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	**ANALYSIS OF AIRCRAFT STRUCTURES**				
Course Code	AAE06				
Program	B.Tech				
Semester	IV				
Course Type	CORE				
Regulation	R-16				
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	Theory of Structures	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
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). 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
%	Remember
%	Understand
%	Apply
%	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:

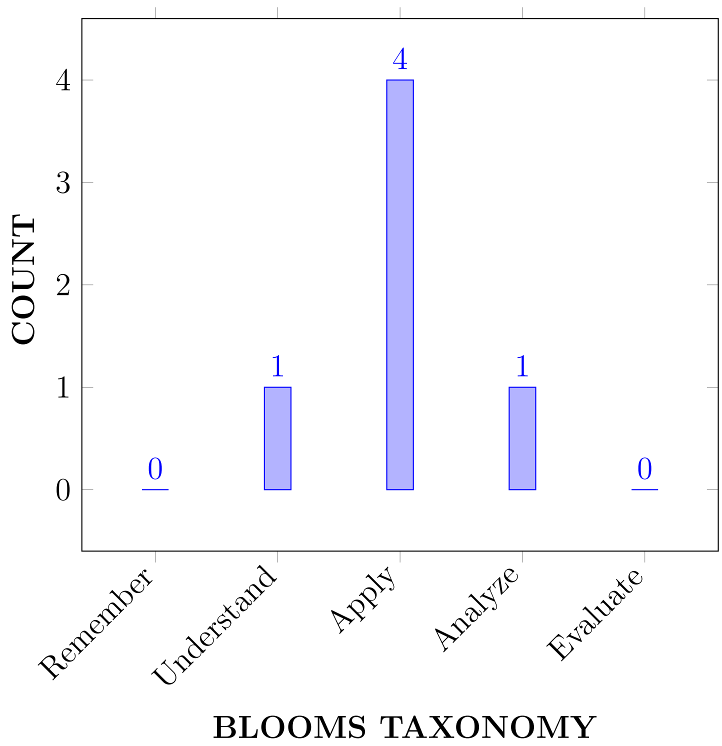
I	The application of mathematical principles on aircraft structural components and determination of deflections and stresses under various loading conditions.
II	The concepts of thin plate theory, phenomena of thin plate structural instability, analysis of bending, shear and torsion of thin walled beams
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


COUNT
BLOOMS TAXONOMY
0
1
2
3
4
Remember
Understand
Apply
Analyze
Evaluate
0
1
4
1
0

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	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	-	-	-	-	-	-	-	-	-	-	-	-	3
CO 5	3	-	-	2	-	-	-	-	-	-	-	-	-	-	-
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		
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	
	Content Delivery		
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: Discussion on definations and terminologies related to Aircraft structural components and various energy methods	CO 1	R2:7.5
2	Module II: Discussion on definations and terminologies related to thin rectangular plates and solutions related to plates instabilities.	CO 2	R2:7.5
3	Module III:Discussion on definations and terminologies related to bending, shear and torsion of thin walled beams	CO 3, CO 4	R2:7.5
4	Module IV: Discussion on definations and terminologies related to structual idealisation of an aircraft components.	CO 5	R2:7.5
5	Module V:Discussion on definations and terminologies related to Fuselage and landing gears.	CO 6	R2:7.5
DISCUSSION OF QUESTION BANK			
1	Module I:Numerical problems related to aircraft structural components, energy methods.	CO 1	R4:2.1
2	Module II:Numerical problems related to thin rectangular plates, stiffined panels and thin plate instability.	CO 2	T4:7.3
3	Module III: Numerical problems related to bending, shear and torsion of thin walled beams.	CO 3, CO 4	R4:5.1
4	Module IV:Numerical problems related to structural idealisation of fuselage and wings.	CO 5	T1:7.5
5	Module V:Numerical problems related to fusel FUSELAGE, WING AND LANDING GEAR	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,AE**
Dr V Varun,Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**COMPLEX ANALYSIS AND PROBABILITY DISTRIBUTIONS**				
Course Code	AHS004				
Program	B. Tech				
Semester	IV				
Course Type	Foundation				
Regulation	IARE-R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Ms B Praveena, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
10+2	-	-	-

II COURSE OVERVIEW:

The course focuses on more Advanced Engineering Mathematics which provide with the relevant mathematical tools required in the analysis of engineering problems and scientific professions. The course includes complex functions and differentiation, complex integration, power series expansion of complex function and Probability of single random variables with its distributions. The mathematical skills derived from this course form a necessary base to analytical and design concepts encountered in the program.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Complex Analysis and probability distributions	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
36 %	Understand
64 %	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	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 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:

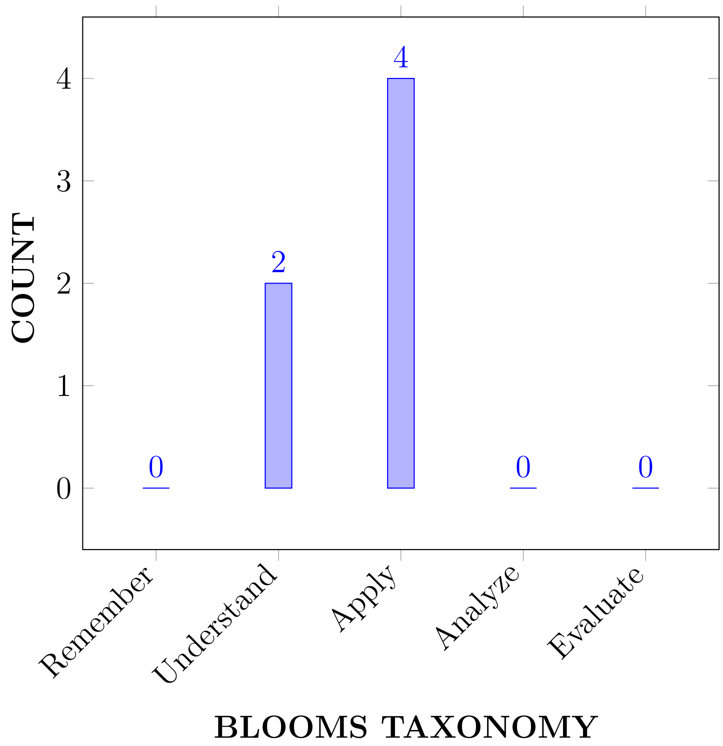
I	The applications of complex variable and conformal mapping in two dimensional complex potential theories.
II	The fundamental calculus theorems and criteria for the independent path on contour integral used in problems of engineering
III	Enrich the knowledge of probability on single random variables and probability distributions

VII COURSE OUTCOMES:

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

CO 1	**Identify** the fundamental concepts of analyticity and differentiability for finding complex conjugates , conformal mapping of complex transformations.	Apply
CO 2	**Apply** integral theorems of complex analysis and its consequences for the analytic function with derivatives of all orders in simple connected region.	Apply
CO 3	**Extend** the Taylor and Laurent series for expressing the function in terms of complex power series.	Apply
CO 4	**Apply** Residue theorem for computing definite integrals by using the singularities and polesof real and complex analytic functions over closed curves.	Apply
CO 5	**Explain** the concept of random variables and types of random variables by using suitable real time examples.	Understand
CO 6	**Interpret** the parameters of random variate Probability distributions by using their probability functions, expectation and variance.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	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	GMake 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 OUT COMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	**PO 1**	Identify the basic properties of analytic functions which are closed with respect to the fundamental operations of arithmetic (knowledge), algebra and applicability in solving majority of functions in various engineering problems by applying Mathematical principles.	2
CO 2	**PO 1**	Apply the integral theorem of complex analysis (knowledge) and its consequences to the analytic function for solving complex problems by applying the principal problems of mathematics.	2
	PO 2	Identify the problem statement to build extensions of Cauchy's theorem and application of necessary condition to vanish a contour integral around the simple connected regions from the provided information and data in reaching substantiated conclusions by using principles of mathematics.	4
	PO 4	Apply quantitative methods to simplify the calculation of certain contour integrals (knowledge) on simply connected regions in order to solve engineering problems.	2
CO 3	**PO 1**	Apply the knowledge of geometric series that enable us to use Cauchy's integral formula for understanding power series representations of analytic functions by applying the principles of mathematics.	2
	PO 2	IdeIdentify the problem formulation and abstraction of rational complex functions for expressing in negative or positive terms of power series (knowledge) using Laurent's series and Taylor's series by applying the principles of mathematics.	4

CO 4	**PO 1**	Apply the method of finding residues of given real or complex integrand (knowledge) the singular points and poles of complex functions and applicability of Residue theorem to solve definite and indefinite complex integrals by applying the principles of mathematics.	2
	PO 4	Make use of the quantitative methods of finding residues for evaluating line integrals (length of curve) of analytic functions over closed curves and applicability of Residue theorem by applying the principles of mathematics.	2
CO 5	**PO 1**	Explain(understanding) the concept of random variables and Calculate the expected values, variances (Application) of the discrete and continuous random variables (knowledge) for making decisions in complex engineering problems under randomized probabilistic conditions by using principles of mathematics.	3
	PO 2	Apply the concepts of discrete and continuous probability distributions which involves the role of Arithmetic mean, median, mode and variance, mathematical functions (principles of mathematics)for solving complex engineering problems under probabilistic conditions	1
CO 6	**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.	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	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	4	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	-	-	2		-	-	-	-	-	-		-	-	-
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	66.7	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.7	40.0	-	20	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.7	40.0	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.7	-	-	20		-	-	-	-	-	-		-	-	-
CO 5	100	-	-	10	-	-	-	-	-	-	-	-	-	-	-
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	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	4	-	3	-	-	-	-	-	-	-	-	-	-	-
AVER-AGE	3	2	-	1	-	-	-	-	-	-	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓PO4	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	Tech-talk	✓	Concept video	✓
Assignments	-				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**COMPLEX FUNCTIONS AND DIFFERENTIATIONS**
	Complex functions and its representation on argand plane, concepts of limit, continuity, differentiability, analyticity, Cauchy-Riemann conditions and harmonic functions; Milne-Thomson method, Bilinear Transformation
MODULE II	**COMPLEX INTEGRATION**
	Line integral: Evaluation along a path and by indefinite integration; Cauchy's integral theorem; Cauchy's integral formula; Generalized integral formula; Power series expansions of complex functions And contour Integration: Radius of convergence.
MODULE III	**POWER SERIES EXPANSION OF COMPLEX FUNCTION**
	Expansion in Taylor's series, Maclaurin's series and Laurent series. Singular point; Isolated singular point; Pole of order m; Essential singularity; Residue: Cauchy Residue Theorem. Evaluation of Residue by Laurent Series and Residue Theorem. Evaluation of integrals of the type $\int_0^{2\pi} f(\cos\theta, \sin\theta)d\theta$ and $\int_0^{\infty} f(x)dx$
MODULE IV	**SINGLE RANDOM VARIABLES**
	Random variables: Discrete and continuous, probability distributions, mass function-density function of a probability distribution. Mathematical expectation. Moment about origin, central moments, moment generating function of probability distribution.
MODULE V	**PROBABILITY DISTRIBUTIONS**
	Binomial, Poisson and normal distributions and their properties.

TEXTBOOKS

1. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley and Sons Publishers, 10th Edition,2010

2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 43rd Edition, 2015.

REFERENCE BOOKS:

1. T.K.V Iyengar, B. Krishna Gandhi, "Engineering Mathematics - III", S. Chand and Co., 12th Edition, 2015.

2. Churchill, R.V. and Brown, J.W, "Complex Variables and Applications", Tata Mc Graw-Hill, 8th Edition, 2012.

WEB REFERENCES:

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

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 T1: 4.1
OBE DISCUSSION			
1	Course Objectives, Course Outcomes, Program Outcomes, Co-PO Mapping		
CONTENT DELIVERY (THEORY)			
2	Understanding the complex function in Argand plane	CO 1	T1:12.4, R1:4.13
3	Apply the limit of a complex function	CO 1	T1:12.4, R1:4.13
4	Apply the continuity of a complex function	CO 1	T1:12.4, R1:4.13
5	Apply the differentiability and analyticity of a complex function	CO 1	T1:12.4, R1:4.13
6	Identify and Apply the of Cauchy-Riemann conditions in Cartesian and Polar forms	CO 1	T1:12.4, R1:4.13
7	Evaluate the Harmonic Conjugates	CO 1	T1:12.4, R1:4.13
8	Apply the Milne-Thomson method to find the Analytic function	CO 1	T1:12.4, R1:4.13
9	Apply the properties of Bilinear transformation for complex functions.	CO 1	T1:12.5, R1:8.8
10	Evaluate the Line Integral for a given path	CO 2	T1:13.1, R1:5.3
11	Apply the Cauchy's integral theorem in a given plane	CO 3	T1:13.1, R1:5.3
12	Apply the Cauchy's integral formula for evaluating contour integration	CO 3	T1:13.1, R1:5.3
. 13	Apply the Cauchy's general integral formula for evaluating contour integration.	CO 3	T1:13.1, R1:5.3
14	Define the Power series expansions of complex functions and contour Integration	CO 4	T1:14.1, R1:6.1
15	Evaluate the Radius of convergence of power series complex function	CO 4	T1:14.1, R1:6.1
16	Identify the types of power series expansions	CO 4	T1:14.1, R1:6.1
17	Define the types of Singularities and its nature	CO 4	T1:15.2 , R1:6.6
18	Define the concept of Residues	CO 4	T1:15.2 , R1:6.6

19	Evaluate the Residues of complex functions.	CO4	T1:15.2 , R1:6.6
20	Evaluate of contour integrals by Residue theorem.	CO4	T1:15.2 , R1:6.6
21	Establish the basic concepts of Random variables	CO 5	T2: 7.14, R1:1.6
22	Analyze the types of Probability distributions	CO5	T2: 7.14, R1:1.6
23	Discuss the Mass function, Density function	CO5	T2: 7.14, R1:1.6
24	Asses the Expectations of Probability Distribution	CO5	T2: 7.14, R1:1.6
25	Discuss and Estimate the Moment and Central moments	CO 5	T2: 16.6, R1:7.36
26	Discuss and Estimate the Moment Generating functions	CO 5	T2: 16.8, R1:7.41
27	Analyze and Apply the parameters	CO 5	T2: 16.9, R1:7.42
28	Analyze and Apply the Poisson Distribution parameters	CO 6	T2: 16.9, R1:7.42
29	Analyze and Apply the Normal Distribution parameters	CO 6	T2: 16.9, R1:7.42
30	Complex functions differentiation and integration: Complex functions and its representation on argand plane	CO 2	T2: 16.9, R1:7.42
31	Concepts of limit, continuity	CO 1	T1:12.4, R1:4.13
32	Establish the basic concepts of Random variables	CO5	T2: 7.14 R1:1.6
33	Analyze the types of Probability distributions	CO5	T2: 7.15 R1:16.5
34	Discuss the Mass function, Density function	CO8, CO9	T2:11.3 R1:16.5
35	Asses the Expectations of Probability Distribution	CO5	T2: 16.5 R1:7.32
36	Discuss and Estimate the Moment and Central moments	CO 5	T2: 16.6 R1:16.9
37	Discuss and Estimate the Moment Generating functions	CO 5	T2: 11.4 R1:16.18
38	Analyze and Apply the Binomial Distribution parameters	CO6	T2: 16.8 R1:7.41

39	Analyze and Apply the Poisson Distribution parameters	CO 6	T1:17.5-17.6, R1:16.3.1
40	Analyze and Apply the Normal Distribution parameters	CO 6	T2: 16.9, R1:7.422 ,
41	Problems on integral formula	CO 4	T1:13.4, R1:5.10
PROBLEM SOLVING/ CASE STUDIES			
42	Problems on generalized integral formula	CO 2	T1:14.1, R1:6.1
43	Problems on generalized integral formula	CO 2	T1:14.1, R1:6.1
44	Problems on power series expansions of complex functions Expansion in Taylor's series	CO 3	T1:14.1, R1:6.1
45	Problems on Maclaurin's series	CO 3	T1:15.2 , R1:6.6
46	Problems on Laurent series	CO 3	T1:15.3, R1:7.9
47	Problems on types of singularities , pole of order m	CO 4	T1:15.3, R1:7.9
48	Problems on evaluation of residue by Laurent Series	CO 3	T1:15.3, R1:7.9
49	Problems on Residue Theorem.	CO 4	T1:14.1, R1:6.1
50	Problems on definite integrals of the type -I	CO 3	T1:15.3, R1:7.9
51	Problems on indefinite integrals of type-II	CO 4	T1:15.3, R1:7.9
52	Problems on Binomial Distribution	CO 6	T2: 16.9, R1:7.42
53	Problems on Poisson Distribution	CO 6	T2: 16.9, R1:7.42
54	Problems on Normal Distribution	CO 6	T2: 16.9, R1:7.42
55	Problems on Moment Generating functions	CO 5	T2: 16.7, R1:7.36
56	Definitions and terminology Cauchy-Riemann conditions in Cartesian and Polar forms	CO 1,CO2	T1:12.4, R1:4.13
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Definitions and terminology the differentiability and analyticity of a complex function	CO 1,CO2	T1:12.4, R1:4.13
58	Definitions and terminology Milne-Thomson method to find the Analytic function	CO 1,CO2	T1:12.4, R1:4.13
59	Definitions and terminology on Cauchy's general integral formula for evaluating contour integration, on types of singularities , pole of order m	CO 4	T1:13.4, R1:5.10

60	Definitions and terminology on probabilities.	CO 5	T1:15.2 , R1:6.6
61	Definitions and terminology on distributions	CO 6	T1:12.4, R1:4.13
DISCUSSION OF QUESTION BANK			
62	Discussion of Question Bank of Module II Complex functions and differentiation	CO 1	T1:12.3, R1:4.4
63	Discussion of Question Bank of Module II complex integration	CO 2	T1:12.5, R1:8.8
64	Discussion of Question Bank of Module III power series expansion of complex function	CO3,CO 4	T1:15.1, R1:7.4
65	Discussion of Question Bank of Module IV Random variables	CO 5	T2: 7.15, R1:1.65
66	Discussion of Question Bank of Module V Probability distributions	CO 6	T2: 16.9, R1:7.42

Course Coordinator: **HOD, EEE**
Ms B Praveena , Assistant Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

<table>
<tr><td>Course Title</td><td colspan="5">AEROSPACE STRUCTURES LABORATORY</td></tr>
<tr><td>Course Code</td><td colspan="5">AAEB11</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td>IV</td><td colspan="4">AE</td></tr>
<tr><td>Course Type</td><td>Laboratory</td><td colspan="4"></td></tr>
<tr><td>Regulation</td><td>R-18</td><td colspan="4"></td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>3</td><td>1.5</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Dr V Varun, Associate Professor</td></tr>
</table>

I COURSE OVERVIEW:

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

II COURSE PRE-REQUISITES:

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

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

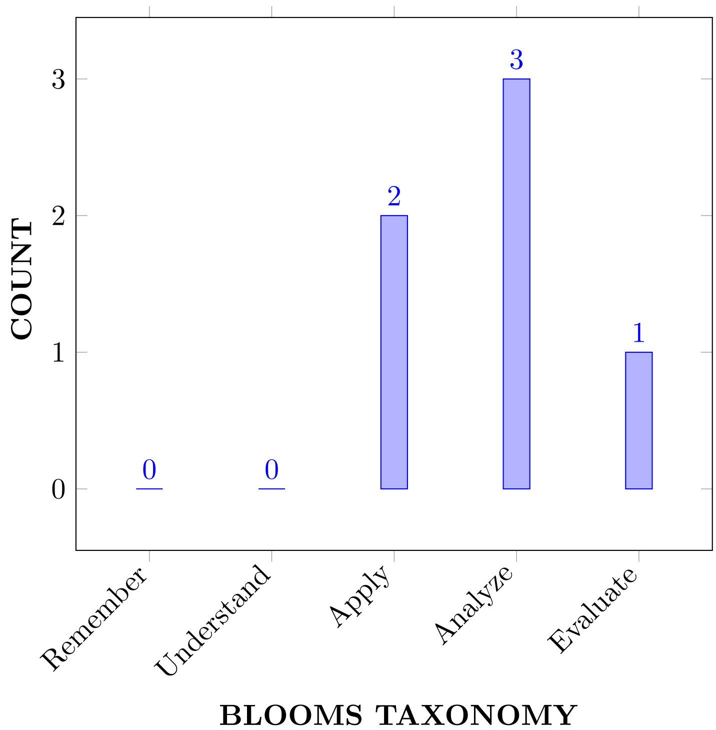
I	The basic knowledge on the mechanical behavior of materials such as aluminum, mild steel, and cast iron for determining its behavior under different load conditions .
II	The identification of crack/flaws using Non Destructive Testing (NDT) methods for choosing proper materials in engineering applications .
III	Understand the concept of shear centre for open and Closed section 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.	Analyze
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.	Analyze
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.	Evaluate
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.	Aply
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	Identify (knowledge) the basic properties of various engineering materials, to a considerable extent appreciate (understanding) their importance and applicability (apply) in solving (complex) structural engineering problems by applying the principles of mathematics, science.	3
	PO 2	Understand the (given **problem statement**) and material properties for (provided **information and data**) in reaching substantiated conclusions by the interpretation of results	3

	PSO 3	Apply (**knowledge**) properties of various types matrials and stress-strain curves (apply) for solving design problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 2	PO 1	Apply the basic equations of science for various phenomena of structural systems and use **mathematical principles** for deriving (complex) structural engineering equations by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals** of structural mechanics.	3
	PO 3	Understand the given **problem statement** and formulate (complex) buckling phenomena and system for deriving various governing equations of structural 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 structural 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 3	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** to determine shear center for a given beam geometry, to avoid torsion under the applied load and behaviour of a beam deflection in out of plane	2
	PO 5	Using first **principles of Sciences and Engineering fundamentals** understand the concept of shear center and its importance in design of aerospace structures.	2
	PSO 3	Extend the focus to **understand the innovative and dynamic challenges** involves in evaluation of shear center and unsymmetrical beam deflection.	1
CO 4	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** to determine the material properties to design a structure with maximize strength and determine the shear stresses in tension field beams	2
	PO 5	Using first **principles of Sciences and Engineering fundamentals** understand the concept of engineering materials to optimze the strength and weight of a given structure and failure of tension field beams.	2
	PSO 3	Extend the focus to **understand the innovative and dynamic challenges** involves in evaluation of light weight materials involved in construction of aircraft structures and stresses in tension field beams.	1
CO 5	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** for determining flaws in a given materials.	2

	PO 5	Using first **principles of Sciences and Engineering fundamentals** understand the concept flaw detections and crack growths under given loading conditions.	2
	PSO 3	Extend the focus to **understand the innovative and dynamic challenges** involves in flaw detections techniques.	1
CO 6	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** for determining the response of vibrating machines such as acceleration, velocity and displacement etc for designing the new equipment's under desirable conditions	2
	PO 5	Using first **principles of Sciences and Engineering fundamentals** to understand the concept of vibration test equipment for avoiding failures due to vibrations like fatigue	2
	PSO 3	Extend the focus to **understand the innovative and dynamic challenges** involves in evaluation of vibration testing equipment design.	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 5	PSO 3
CO 1	3	3	-	-	3
CO 2	3	-	2	2	3
CO 3	2	-	-	2	1
CO 4	2	-	-	2	1
CO 5	2	-	-	2	1
CO 6	2	-	-	2	1

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	**UNSYMMETRICAL BEAM BENDING TEST**
	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.

TEXT BOOKS

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

REFERENCE BOOKS:

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

XV COURSE PLAN:

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

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

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**
Dr V Varun,
Associate Professor

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**AIRCRAFT MATERIALS AND PRODUCTION**				
Course Code	AAE005				
Program	B.Tech				
Semester	IV				
Course Type	CORE				
Regulation	R 16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. S.Devraj, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS005	I	Engineering Chemistry
B.Tech	AME002	II	Engineering Mechanics
B.Tech	AAE002	III	Theory of Structures

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	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
70%	Understand
10%	Apply
0 %	Analyze

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

Component	Theory		Total Marks
Type of Assessment	CIE Exam	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 below table

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

VI COURSE OBJECTIVES:

The students will try to learn:

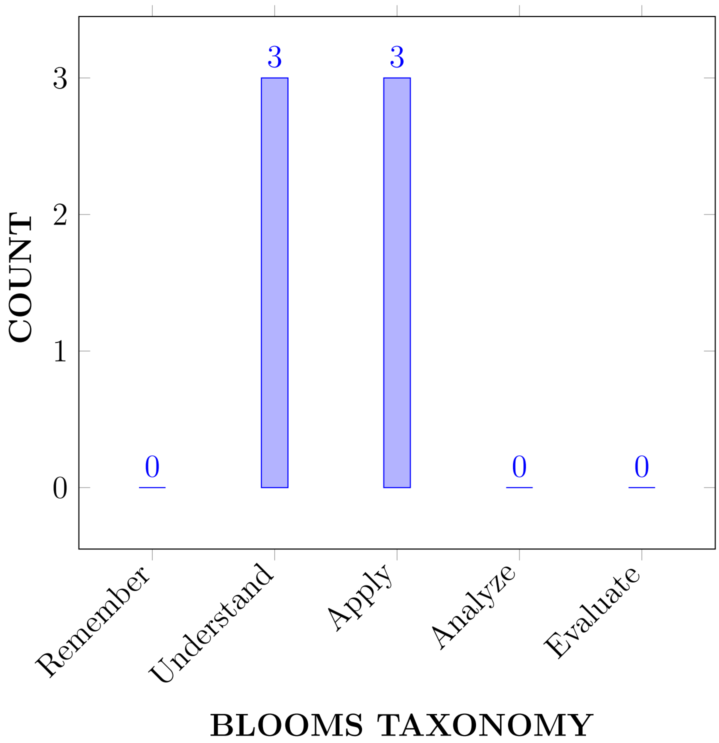
I	The methods of improving the mechanical properties of aerospace materials and their alloys using heat treatment processes and corrosion prevention methods.
II	The concepts of welding, casting, forming, riveting process and quality inspection techniques used in manufacturing the aerospace components 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	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 formulation and evaluation of aircraft elastic bodies for characterization of aero elastic phenomena.	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 joining process (apply) in producing shapes of objects 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
	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 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 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
CO 5	PO 1	Apply (knowledge) of CNC machines (understanding) in manufacturing process (apply) for production of aircraft components by applying the principles of science and Engineering.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	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 their processing (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. S.Devaraj, Assistant Professor

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

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION

Course Title	AIRCRAFT MATERIALS AND PRODUCTION LABORATORY				
Course Code	AAE105				
Program	B.Tech				
Semester	IV	AE			
Course Type	CORE				
Regulation	R 16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Mr.S.Devaraj, 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	AME101	I	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:

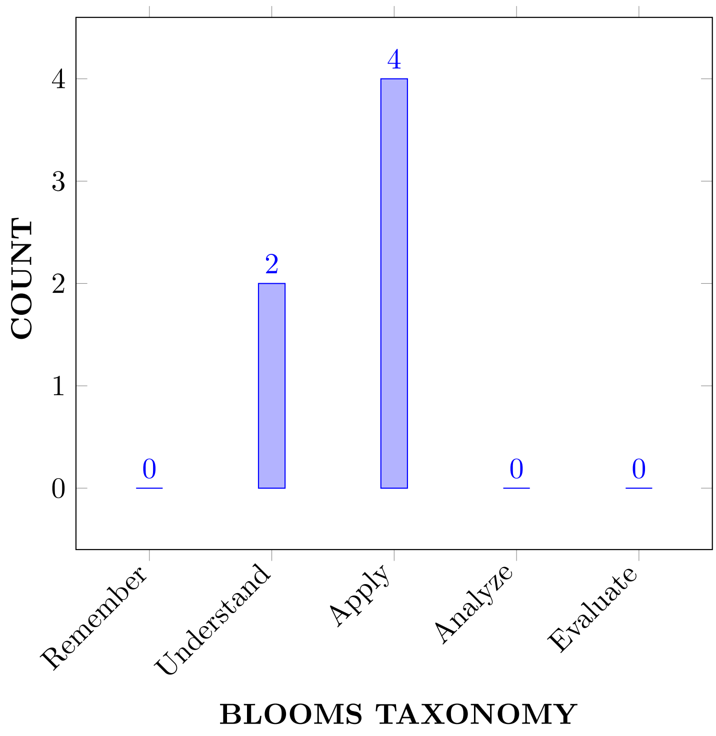
I	Understand the basic material properties to identify the suitable applications in aerospace industries.
II	Illustrate other conventional machining techniques required for aircraft production.
III	Learn the tooling and material joining technique used in aircraft assembly.

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**
	Introduction- lathe machine, plain turning, Step turning and grooving, Taper turning-compound rest/offset method and Drilling using lathe, External threading-Single start
WEEK IV	**SHAPING and SLOTTING**
	Shaping-V-Block and Slotting-Keyways.
WEEK V	**MILLING and GRINDING**
	Grinding-Cylindrical /Surface/Tool and cutter. Milling-Polygon /Spur gear, Gear hobbing-Helical gear.
WEEK VI	**DRILLING**
	Drilling, reaming, counter boring, Counter sinking and Taping
WEEK VII	**CNC MACHINING**
	Basic operations, Introduction to CNC programming.
WEEK VIII	**WELDING PROCESS-I**
	Gas Welding, Brazing and Soldering.
WEEK IX	**WELDING PROCESS-II**
	Arc welding and Spot welding
WEEK X	**BASIC CASTING**
	Preparation of casting with simple patterns.
WEEK XI	**RIVETING ALUMINIUM SHEETS**
	Solid and Blind Rivets on aluminium sheets.

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 metal joining technique with the help of rivets.	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.S.Devaraj, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Aeronautical Engineering**				
Course Title	**HIGH SPEED AERODYNAMICS**				
Course Code	AAE008				
Program	B.Tech				
Semester	Five				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	G Satya Dileep, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AAE004	IV	Low Speed 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	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

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

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

be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

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

VI COURSE OBJECTIVES:

The students will try to learn:

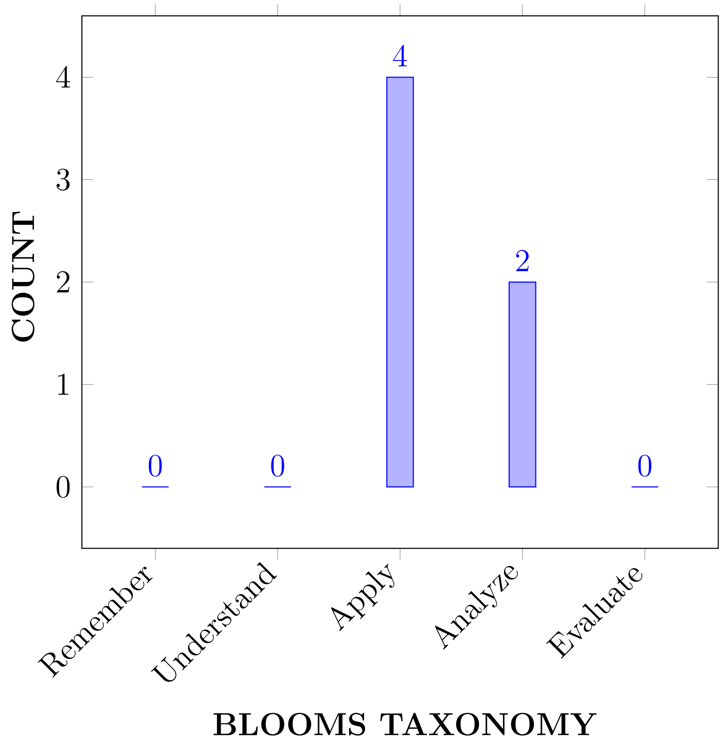
I	Basic concepts of compressible flow, governing equations of compressible flow, compressibility effect at high speeds and their importance on the design of high-speed vehicles.
II	The wave formations, propagation in supersonic flow field and their resultant effect on flow properties variations.
III	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.

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	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	1	CIA/Quiz/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	CIA/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	CIA/Quiz/AAT
PO 5	Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1	CIA/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.	1	CIA/Quiz/AAT
PO 12	Life-Long Learning: Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	1	CIA/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 technology and computer aided engineering in aeronautical systems including air traffic controls standards.	2	CIA/Quiz/ 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/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** principals of mathematics to build the governing equations for compressible flows using the knowledge of **mathematics and science fundamentals.**	2
	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	**Apply** principals of mathematics to build the governing equations for compressible flows using the knowledge of **mathematics and science 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 importance of compressibility and continuum postulate by applying condition for function to be **analytic principles of mathematics and the Engineering knowledge.**	3
	PO 3	**Apply** principals of mathematics to build the governing equations for compressible flows using the knowledge of **mathematics and science fundamentals.**	2
	PO 4	**Apply** principals of mathematics to build the governing equations for compressible flows using the knowledge of **mathematics and science 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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
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	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	**Apply** principals of mathematics to build the governing equations for compressible flows using the knowledge of **mathematics and science fundamentals.**	2
	PO 10	**Apply** principals of mathematics to build the governing equations for compressible flows using the knowledge of **mathematics and science fundamentals.**	2
	PO 12	**Apply** principals of mathematics to build the governing equations for compressible flows using the knowledge of **mathematics and science fundamentals.**	2
	PSO 3	**Understand** the behavior of flow through constant area passage with heat addition and friction by **by 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	**Apply** principals of mathematics to build the governing equations for compressible flows using the knowledge of **mathematics and science fundamentals.**	2
	PO 3	**Apply** principals of mathematics to build the governing equations for compressible flows using the knowledge of **mathematics and science fundamentals.**	2
	PO 4	**Apply** principals of mathematics to build the governing equations for compressible flows using the knowledge of **mathematics and science 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 5	PO 1	**Identify** the importance of perturbation theory on linearizing compressible flow governing equation by using the**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	**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 two-dimensional airfoil **for innovative solutions, and understand the economic context** .	2
	PO 5	**Build** the linear velocity potential equation of steady irrotational isentropic compressible flow for **analyzing the given engineering problems and generate the solution.**	2
	PSO 1	**Understand** the behavior of flow through constant area passage with heat addition and friction by **by science and engineering fundamentals.**	2
	PSO 3	**Understand** the behavior of flow through constant area passage with heat addition and friction by **by science and engineering fundamentals.**	2
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	Understand the given **problem statement** of compressible flow over a supersonic vehicle from the provided **information and data.**	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 the given **problem statement** of compressible flow over a supersonic vehicle from the provided **information and data.**	3
	PSO 1	**Understand** utilization of optical flow visualization to analyses the aerodynamic characteristics of aircraft components for **design and development of new products.**	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	PO 1,PO 2	SEE Exams	PO 1,PO 2, PO3	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 3	Open Ended Experiments	-
Assignments	PO 1, PO 2	Tech talk	PO 2	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 DIMENSIONAL 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:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1			
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	CO 1	T1
2	SHOCK AND EXPANSION WAVES	CO 2	T1
3	DIMENSIONAL AND QUASI ONE DIMENSIONAL FLOW	CO 3,4	T1
4	APPLICATIONS OF COMPRESSIBLE FLOWS AND NUMERICAL TECHNIQUES	CO 5	T1
5	EXPERIMENTAL METHODS IN COMPRESSIBLE FLOWS	CO 6	T1

Signature of Course Coordinator **HOD,AE**

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**COMPUTER AIDED AIRCRAFT ENGINEERING DRAWING**				
Course Code	AAE106				
Program	B.Tech				
Semester	V	AE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Mr. G Rohan, Assistant Professor				

I COURSE OVERVIEW:

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

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME102	II	Computer Aided Engineering Drawing Practice

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner,

both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

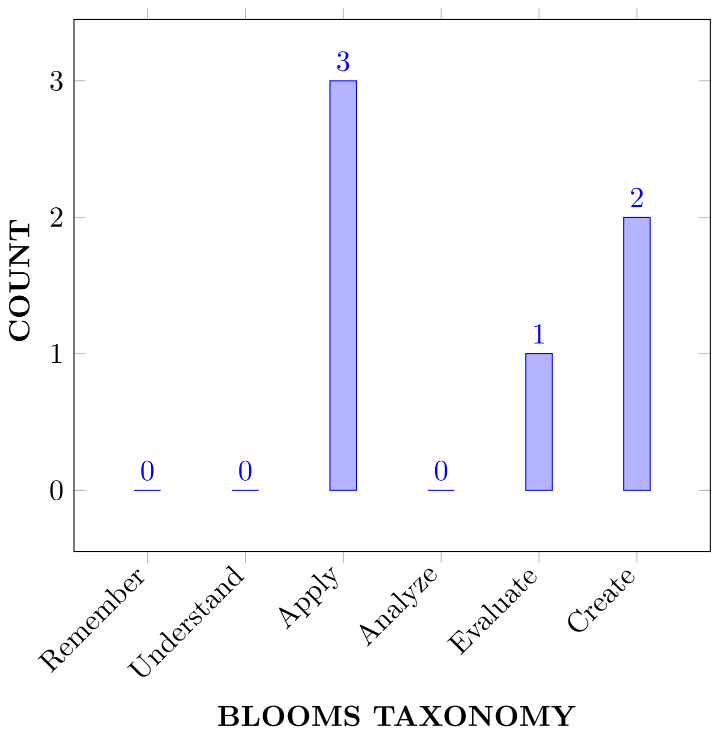
I	Understand the concepts and various tools used in design module.
II	Understand the design of typical structural components.
III	Understand the design of typical aircraft components.
III	Understand the design of three view diagram of a typical aircraft.

VII COURSE OUTCOMES:

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

CO 1	**Choose** appropriate tools and profiles for developing the required sketch using the Sketcher workbench.	Apply
CO 2	**Make use of** wireframe elements, surfaces, trim elements and powercopies for constructing the complex surfaces.	Apply
CO 3	**Utilize** different geometric and dimensioning symbols and industry standards for the preparation of technical mechanical drawings.	Apply
CO 4	**Select** appropriate tools available in assembly workbench for creating three-dimensional assemblies incorporating multiple solid models.	Evaluate
CO 5	**Build** components using sketch Based features, perform sheet metal operations and correctly organize the tree for having maximum compatibility for editing or modifying the model.	Create
CO 6	**Develop** amodel from drawing provided and draw conclusions for designing various aircraft components by utilizing different workbenches.	Create

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises

PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Lab Exercises
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	Lab Exercises
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	Lab Exercises
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Lab Exercises
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	**Justification for mapping (Students will be able to)**	No. of Key Competencies
CO 1	PO 1	Use the knowledge of **engineering fundamentals, basic knowledge of engineering drawing(Own Discipline)** and **understanding the design requirements (Own Discipline)** to select appropriate tools for the desired profile.	2
	PO 2	**Identify the options** available that can give competency for creating multiple drawing and modification commands in CATIA and **interpret the positive results** of designs in the sketcher workbench.	2

	PO 5	Identify the suitable **modern software** in order create, select and the apply for engineering drawing skills to obtain accurate part.	3
	PO 9	Understand the engineering drawing by the geometery either by **individual or team work** to design the geometry using CATIA .	3
	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments.	2
	PO 12	Apply the desigining skills learnt in the CATIA lab to identify the method for **real life problems** using suitable Workbench	2
	PSO 3	Outline the drawing methods adopted in **CATIA laboratory** for **designing** of engieneering models **innovative career** path in industry usage.	2
CO 2	PO 1	Use the knowledge of **engineering fundamentals, basic knowledge of engineering drawing** to identify the different tools that are to be used and **obtain the positive results.**	3
	PO 2	**Identify the** tools that are available in CATIA (wireframe, surfaces) for creating aircraft components surfaces models.	2
	PO 5	Identify the suitable **modern software** in order create, select and the apply for desgin of surface bodies.	3
	PO 9	Understand the CATIA design methodologies either by **individual or team work** to design the surface models using CATIA .	3
	PO 10	Make use of **communication skills to write lab related documents** for effective communication with diverse engineering segments.	2
	PO 12	Apply the desigining skills learnt in the CATIA lab to identify the method for **real life problems** using suitable Workbench	2
	PSO 3	Outline the drawing methods adopted in **CATIA laboratory** for **designing** of engieneering models **innovative career** path in industry usage.	2
CO 3	PO 1	Use the knowledge of **engineering fundamentals and basic knowledge of engineering drawing (Own Discipline) to obtain the desired features** in the tool.	3
	PO 5	Identify the suitable **modern software (CATIA)** in order create, select and the apply for desgin of aircraft components using Geometric Dimensions and Tolrances.	3
	PO 9	Understand the appropriate Geometric Dimension and Tolrances methods to draft an engineering design either by **individual or team work** using CATIA .	3
	PO 10	Make use of **communication skills to write lab related documents** for effective communication with diverse engineering segments.	2

	PO 12	Apply the Geometric Dimensions and Tolrances skills learnt in the CATIA lab to identify the method for **real life problems** using suitable Workbench	2
	PSO 3	Outline the drawing methods adopted in **CATIA laboratory** for **designing** of engieneering models **innovative career** path in industry usage.	2
CO 4	PO 1	Apply **engineering fundamentals** and **basic knowledge of engineering drawing** to assemble tools present in CATIA to develop product with joining of individual components.	3
	PO 2	Understand the basic tools available in assembly workbench with **engineering drawing** to enhance the ability to draw conclusions from **the given data provided**	2
	PO 5	Identify the suitable **modern software (CATIA)** in order create, and assemble the designed individual aircraft components for developing the product.	3
	PO 9	Understand the appropriate assembly tools either by **individual or team work** using CATIA for designing a right product.	3
	PO 10	Make use of **communication skills to write lab related documents** for effective communication with diverse engineering segments.	2
	PO 12	Apply the assembly knowledge learnt in the CATIA lab to identify the method for **real life problems** using suitable tools	2
	PSO 3	Outline the drawing methods adopted in **CATIA laboratory** for **designing** of engieneering models **innovative career** path in industry usage.	2
CO 5	PO 1	Use the knowledge of **engineering fundamentals, basic knowledge of engineering drawing** to select appropriate tools that are available in sheet metal for the designing a right egineering model.	2
	PO 5	Identify the suitable **modern software (CATIA)** to perform the sheet metal operation using the given geometry for developing a product.	3
	PO 9	Understand the design of sheet metal tools either by **individual or team work** using CATIA for designing a sheet metal bodies.	3
	PO 10	Make use of **communication skills to write lab related documents** for effective communication with diverse engineering segments.	2
	PO 12	Apply the sheet metal knowledge in the CATIA lab to identify the appropriate solutions for **real life problems**.	2
	PSO 3	Outline the drawing methods adopted in **CATIA laboratory** for **designing** of engieneering models **innovative career** path in industry usage.	2

CO 6	PO 1	Apply **engineering fundamentals, basic knowledge of engineering drawing** and **manufacturing science** to design an aircraft components in the modern design softwares.	2
	PO 5	Identify the suitable **modern software (CATIA)** to design an aircraft components like wing, fuselage, and landing gear using manufacturing process for developing a product.	3
	PO 9	Understand the basic components present in the aircraft while designing either by **individual or team** using CATIA for designing a aircraft structural component.	3
	PO 10	Make use of **communication skills to write lab related documents** for effective communication with diverse engineering segments.	2
	PO 12	Apply the design knowledge on CATIA workbenchs to design the appropriate models for **real life problems**.	2
	PSO 3	Outline the drawing methods adopted in **CATIA laboratory** for **designing** of engieneering models **innovative career** path in industry usage.	2

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

COURSE OUTCOMES	PROGRAM OUTCOMES						PSO'S
	PO 1	PO 2	PO 5	PO 9	PO10	PO12	PSO 3
CO 1	2	2	3	3	2	2	2
CO 2	2	2	3	3	2	2	2
CO 3	2	-	3	3	2	2	2
CO 4	2	2	3	3	2	2	2
CO 5	2	-	3	3	2	2	2
CO 6	2	-	3	3	2	2	2

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**SKETCHER**
	Interface, Sketch Tools, View Tool bar, Profile Tool bar, Operation Tool bar, Tools , Constrain tool bar,Transformation Tool bar, User Selection Filter, Standards, Visualizations.
WEEK II	**PART DESIGN**
	Sketch Based Features Dress up Features, Transformation Features, Reference Elements, Measure, Thickness, Boolean Operations.
WEEK III	**SHEET METAL DESIGN**
	Walls, Cutting and Stamping, Bending, Rolled Walls.
WEEK IV	**SURFACE DESIGN**
	Surfacer, Operations, Wireframe, Replication.
WEEK V	**ASSEMBLY**
	Product Structure Tools, Constrains.
WEEK VI	**GD and T**
	Introduction to Geometric Dimensioning and Tolerance, Weld Symbols, GD and T Symbols, Types of Tolerances, Types of views, Roughness Symbols.
WEEK VII	**DRAFTING**
	Views, Annotations, Sheet Background.
WEEK VIII	**DESIGN OF AIRCRAFT WING**
	Design of any two types of Aircraft structures.
WEEK IX	**DESIGN OF FUSELAGE**
	Design of fuselage with internal components.
WEEK X	**DESIGN OF NOSE CONE**
	Design of Nose cone structures.
WEEK XI	**DESIGN OF LANDING GEAR**
	Design of Main landing gear and nose landing gear.
WEEK XII	**REVISION**
	Revision.

REFERENCE BOOKS:

1. http://www.ehu.eus/asignaturasKO/DibujoInd/Manuales/R12.manua.catia.v5.pdf
2. http://www.engr.psu.edu/xinli/edsgn497k/TeaPotAssignment.pdf
3. http://www.engr.psu.edu/xinli/edsgn497k/TeaPotAssignment.pdf
4. https://www.3ds.com/fileadmin/general/Terms/Licensed-Program Specifications /CATIA /CATIA. V5R18.p

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Interface, Sketch Tools, View Tool bar, Profile Tool bar, Operation Tool bar, Tools , Constrain tool bar, Transformation Tool bar, User Selection Filter, Standards, Visualizations.	CO 1	R1: 4.1
2	Sketch Based Features Dress up Features, Transformation Features, Reference Elements, Measure, Thickness, Boolean Operations.	CO 1	R1: 3.1
3	Walls, Cutting and Stamping, Bending, Rolled Walls	CO 1	R1: 3.4
4	Surfacer, Operations, Wireframe, Replication.	CO 2	R2: 3.5
5	Product Structure Tools, Constrains.	CO 2	R2: 4.1
6	Introduction to Geometric Dimensioning and Tolerance, Weld Symbols, GD&T Symbols.	CO 3	R2: 4.2
7	Types of Types of views and product assembly techniques.	CO 4	R2: 4.4
8	Views, Annotations, Sheet Background.	CO 5	R2: 5.1
9	Design of any two types of Aircraft structures.	CO 6	R2: 5.2
10	Design of fuselage with internal components.	CO 6	R1: 5.3
11	Design of Nose cone structures.	CO 6	R1:5.4
12	Design of Main landing gear and nose landing gear.	CO 6	R2:5.5

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design aircraft wings at different sweep angles.
2	Design turbine blades by giving possibility to change the twist angle.
3	Assemble different components of a landing gear by top – down method..

Signature of Course Coordinator **HOD,AE**
Mr. Gooty Rohan, Assistant Professor

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**AIRCRAFT PROPULSION**				
Course Code	AAE007				
Program	B.Tech				
Semester	FIVE				
Course Type	Core				
Regulation	R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr.Praveen Kumar Balguri				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME003	IV	Thermodynamics
B.Tech	AAE003	III	Fluid Mechanics and Hydraulics

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).

VI 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
%	Remember
%	Understand
%	Apply
%	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%

VII COURSE OBJECTIVES:

The students will try to learn:

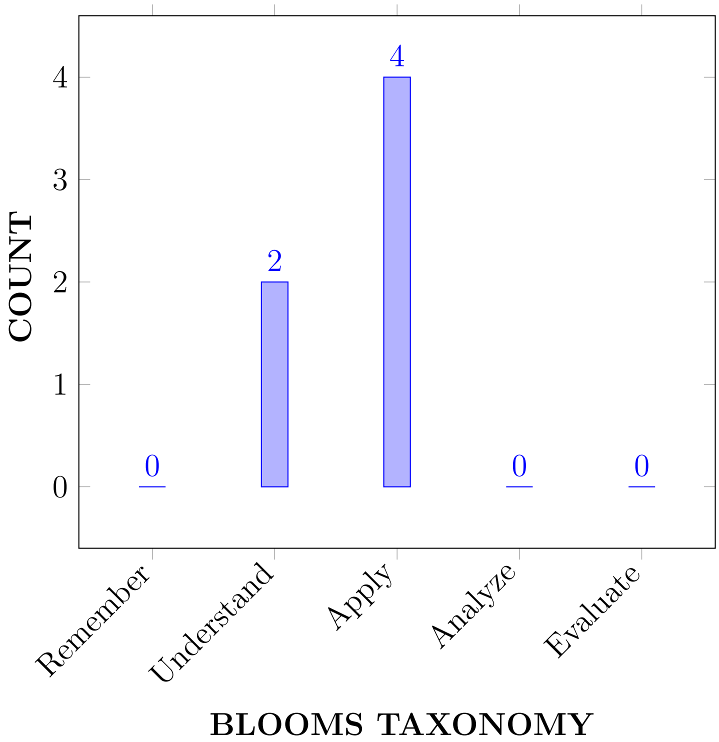
I	The fundamentals of air-breathing propulsion system, their operating principles, and function of an individual component.
II	The geometry of flow inlets, combustion chambers, and factors affecting their performance.
III	The establishment of flow through various inlets and nozzles under different operating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

VIII 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



IX 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

X 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

XI 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

XII 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	✓	✓	-	-		-	-	-	-	-	-	-	-	-	-

XIII 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

XIV 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	-	-	-	-	-	-	-	-	-		-	-	-

XV 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	-	-		-	-	-	-	-	-		-	-	-

XVI 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	-	-

XVII 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					

XVIII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XIX 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:

XX 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	**AIRCRAFT SYSTEMS AND CONTROL**				
Course Code	AAE010				
Program	B.Tech				
Semester	V				
Course Type	CORE				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. Yagya Dutta Dwivedi,Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB03	III	Fluid Mechanics And Hydraulics
B.Tech	AAEB04	III	Basic Electrical and Electronics Engineering

II COURSE OVERVIEW:

Aircraft system is required to introduce for operating an aircraft efficiently and safely, their complexity varies with the type of aircraft. This is involved with many subsystems which must meet demanding customer and operational lifecycle. This course comprises into simpler sub-systems such as electrical systems, hydraulic systems, pneumatic and engine control systems etc., that carry out homogeneous functions. The course also aims to provide methods for safety assessment in relation to the design, reliability, safety and certification of aircraft systems.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Aircraft Systems	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%	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), 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	25	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 25 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - 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:

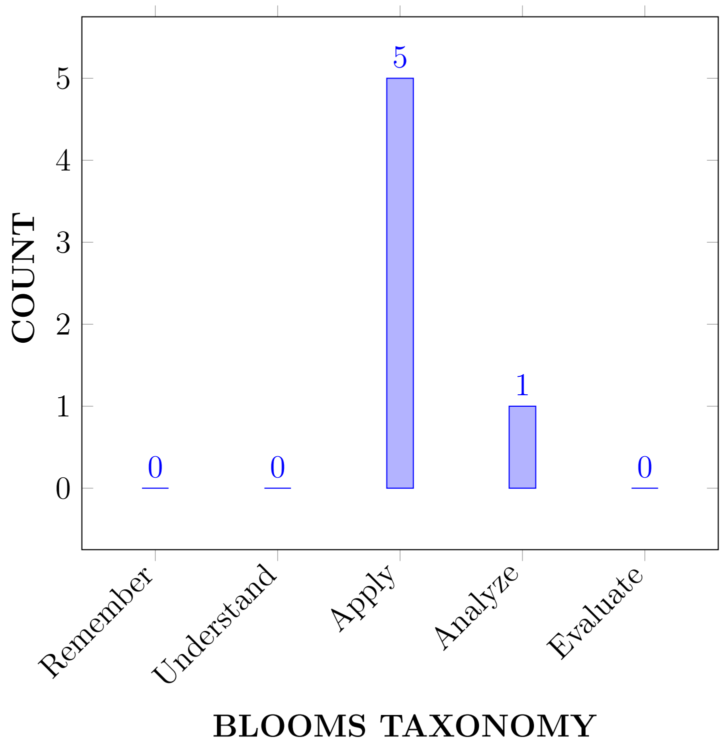
I	The fundamental concepts of aircraft systems its classification and contribution towards the aircraft to fulfill the requirements and missions.
II	Various subsystems : electrical , air conditioning, hydraulic and pneumatic, of an aircraft system.
III	The working principles of engine control and airplane control subsystems of the modern aircraft system.
IV	The design concepts of advanced aircraft systems and controls like fly by wire and autopilots.

VII COURSE OUTCOMES:

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

CO 1	**Develop** the concept of aircraft systems and subsystems like airframe systems, vehicle systems, avionic system and mission systems by using concept of system theory and operating principles.	Apply
CO 2	**Make use of** electrical power generation and air-conditioning systems on the airplane for power distribution and to maintaining pressure and required temperature in the airplane.	Apply
CO 3	**Identify** the principle of operation of hydraulic and pneumatic system with its functions, merits, applications, design requirements and fluid properties for transforming the energy in different hydraulically operated systems.	Apply
CO 4	**Apply** the working principle of aircraft engines its fuel systems and fuel control system	Apply
CO 5	**Develop** the concept of automation in modern flight and engine control systems used in aircraft for safe and sustained flight.	Apply
CO 6	**Examine** the futuristic applications of modern control systems, avionics, and power generation systems used for aerospace applications for enhancing aircraft operations, safety and flight performance.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII 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	**Professional Skills:** Build the prototype of UAVs and aero-foil models for testing by using low speed wind tunnel towards research in the area of experimental aerodynamics.	2	CIE/SEE
PSO 2	**Problem-solving skills:** Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	2	CIE/SEE
PSO 3	**Successful career and Entrepreneurship:** 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	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	**Using basic Scientific principles, Engineering fundamentals** Understanding the concept of aircraft systems and its subsystems	2
	PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for **problem identification and numerical design** of new aircraft systems and associated equipment.	1
CO 2	PO 1	Understand the mission requirements and performance requirements by **using Scientific principles, Engineering fundamentals**	2
	PO 2	Identify the mission requirements, and performance requirements **using opportunity identification for better design system definition**	2
CO 3	PO 1	Make use of electrical power generation **using Scientific principles and fundamentals in Engineering**.	2
	PO 2	Identify the mission requirements, and performance requirements **using opportunity identification for better design system definition**	2
	PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for **problem identification and numerical design** of new aircraft systems and associated equipment.	1
CO 4	PO 1	Understanding the knowledge of the basic air cycle systems and vapor cycle systems by **using scientific principles and engineering fundamentals**.	1
	PO 2	Identify the mission requirements, and performance requirements **using opportunity identification for better design system definition**	1
	PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for **problem identification and numerical design** of new aircraft systems and associated equipment.	1
CO 5	PO 1	**Understanding** the Principal components of Hydraulic system by **using scientific principles and engineering fundamentals**	2
	PO 2	**Understand** the principal operation of hydraulic system its function, merits, application, design requirements and Hydraulic fluid properties using **Problem identification and system defining by using experimental design**.	2
CO 6	PO 1	Understanding the working principles of pneumatic system and break management system in landing gear by using using **scientific principles and engineering fundamentals**.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Application of **Problem identification and system definition** in break management system for quick and easy operation using **experimental design**	1
	PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for **problem identification and numerical design** of new aircraft systems and associated equipment.	1

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	-	-	-	-	-		-	1	-
CO 2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	2	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 4	1	1	-	-	-	-	-	-	-	-	-		-	2	-
CO 5	2	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
CO 1	67	-	-	-	-	-	-	-	-	-	-		-	34	-
CO 2	67	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	67	20	-	-	-	-	-	-	-	-	-	-	-	67	-
CO 4	34	10	-	-	-	-	-	-	-	-	-		-	67	-
CO 5	67	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	67	20	-	-	-	-	-	-	-	-	-		-	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	-	-	-	-	-	-	-	-	-	-		-	3	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 4	1	1	-	-	-	-	-	-	-	-	-		-	3	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	1	-	-	-	-	-	-	-	-	-		-	3	-
TOTAL	16	5	-	-	-	-	-	-	-	-	-	-	-	7	-
AVERAGE	2.7	-	-	-	-	-	-	-	-	-	-	-	-	1.4	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	PO 1, PO 2	SEE Exams	PO 1, PO 2	Assignments	-
Laboratory Practices	-	Student Viva	-	Certification	-
Tech- Talk	PSO 2	Concept Video	PSO 2	Open Ended Experiments	PSO 2
Seminars	-				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO AIRCRAFT SYSTEMS**
	System concepts, sub-systems; Generic system definition, inputs, outputs, feedback, external influence. Aircraft systems- airframe systems, vehicle systems, avionics systems, mission systems and their sub-systems; Specification of requirements, mission requirements, performance requirements.
MODULE II	**ELECTRICAL SYSTEMS AND AIR CONDITIONING, PRESSURIZING SYSTEMS**
	Electrical loads in aircraft. Electrical power generation and control- DC, AC- types. Power distribution- primary, secondary. Power conversion and energy storage; Load protection; Electrical load management systems, 270 V DC systems; Basic air cycle systems; Vapor cycle systems, boost-strap air cycle system; Evaporative Vapor cycle systems; Evaporative air cycle systems; Oxygen systems; deicing and anti-icing systems.
MODULE III	**HYDRAULIC SYSTEMS AND PNEUMATIC SYSTEMS**
	Hydraulic systems: function, merits, application, system loads, design requirements; Principal components; Hydraulic fluid: required properties; Hydraulic piping, pumps, reservoir, accumulator; Pneumatic systems: Advantages;- Working principles ; Typical air pressure system ; Brake system; Typical pneumatic power system ; Components, landing gear systems ; Landing gear and brake management systems.
MODULE IV	**ENGINE CONTROL AND FUEL SYSTEMS**

	Principle of operation of aircraft gas turbine engines; Engine - airframe interfaces; Control of fuel flow, air flow, Limited authority control systems, full authority control systems- examples; Power off takes- need, types; Fuel systems- characteristics, components, operating modes; Fuel tank safety- fuel inserting system.
MODULE V	**AIRPLANE CONTROL SYSTEMS**
	Flight control systems- primary and secondary flight control conventional systems; Power assisted and fully powered flight controls ; Power actuated systems; Engine control systems; Push pull rod system, flexible push full rod system; Control linkages, actuation- types, description and redundancy. Components; Modern control systems; Digital fly by wire systems, control more laws, implementation; Auto pilot system.

TEXTBOOKS

1. Moir, I. and Sea bridge, A, Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration‖, John Wiley, 3rd Edition 2008.
2. Moir, I. and Sea bridge, A, Design and Development of Aircraft Systems- An Introduction‖, AIAA Education Series‖, AIAA, 2004.

REFERENCE BOOKS:

1. 1. Pallett, E.H.J., Aircraft Instruments and Integrated Systems‖, Longman Scientific and Technical 10th Edition, 1992.
2. Harris, D, Flight Instruments and Automatic Flight Control Systems‖, 6th Edition, 2004.
3. 3. Bolton, W., Pneumatic and Hydraulic Systems‖, Butterworth-Heinemann.

WEB REFERENCES:

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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			
CONTENT DELIVERY (THEORY)			
2	Generic system definition, inputs, outputs	CO 1	T1: 1.1-1.2
3	Feedback, external influence. Aircraft systems- airframe systems	CO 1	T1: 1.3-4
4	Vehicle systems	CO1	T1: 1.5-1.6
5	avionics systems	CO1	T1: 1.7

6	Mission systems and their sub-systems	CO1	T2: 1.8
7	Specification of requirements, mission requirements	CO 1	T1:1.9 R1: 2.1
8	Performance requirements	CO1	T1 2-4
9	Electrical loads in aircraft	CO 2	T1: 2.5
10	Electrical power generation and control	CO 2	T1: 2.6
11	DC, AC- types in electric power generation	CO 2	T1: 3.1
12	DC – AC generation procedure and advantages	CO 2	T1: 3.2
13	Power distribution- primary, secondary	CO 2	T2: 3.3
14	Power distribution- secondary	CO 2	T2:3.4
15	Power conversion and energy storage	CO 2	T2: 5.1, R1:4.2-6
16	Power energy storage	CO 2	T2:5.2
17	Methods for conversions and storage of energy	CO 2	T2: 5.3
18	Electrical load management systems, 270 V DC systems	CO2	T2: 5.4, R1: 4.7-8
19	Basic air cycle systems	CO2	T2: 5.5 R3: 3.2
20	boost-strap air cycle system	CO2	T2:5.6
21	Evaporative Vapor cycle systems	CO2	T1:4.5
22	Evaporative air cycle systems	CO2	T2: 4.5
23	Vapor cycle systems	CO2	T2: 4.6
24	Oxygen systems; deicing and anti-icing systems	CO3	T1: 4.1
25	Hydraulic systems: function, merits, application, system loads, design requirements	CO3	T1: 4.2 R2:4.4
26	Principal components; Hydraulic fluid: required properties; Hydraulic piping, pumps, reservoir, accumulator	CO3	T1: 4.3 R3:3.6
27	Pneumatic systems ; Advantages;- Working principles	CO3	T2: 5.2
28	Typical air pressure system ; Brake system	CO3	T2: 5.2
29	Typical pneumatic power system ; Components	CO3	T2: 5.3
30	Landing gear systems; Landing gear and brake management systems	CO4	T1: 6.1-6.2 R3: 5.5
31	Principle of operation of aircraft gas turbine engines	CO 4	T1: 6.3 R2:6.1
32	Engine - airframe interfaces; Control of fuel flow, air flow, Limited authority control systems	CO 4	T1: 6.4 R1:5.5
33	Full authority control systems- examples; power off takes- need	CO 5	T1: 6.5
34	Types; Fuel systems- characteristics, components, operating modes	CO 5	T1: 7.1, R3:4.3-6
35	Fuel tank safety- fuel inserting system.	CO 5	T1: 7.2
36	Flight control systems- primary and secondary flight control conventional systems; Power assisted and fully powered flight controls	CO 5	CO 10v T1: 7.3 R2:3.6 R3:5.2
37	Power actuated systems; Engine control systems; Push pull rod system, flexible push full rod system; Control linkages	CO 6	T1: 7.4, R2:4.1-4.4
38	Actuation- types, description and redundancy.	CO 6	T1: 7.5

39	Components; Modern control systems	CO 6	R2:7.3
40	Digital fly by wire systems, control laws, implementation; Auto pilot system	CO 6	T1: 7.6
PROBLEM SOLVING/ CASE STUDIES			
1	Modern fly by wire design and application	CO1	T1:7.7-8
2	Modern systems used in aircrafts	CO1	T2: 2.1-2.2
3	Fighter aircraft structural systems	CO1	T2: 2.3-2.4
4	Case study of historical development of aircraft systems	CO2	T2: 2.5-2.6
5	A case study on modern aircraft power generation systems	CO2	T2: 4.2
6	AC-DC power generation and a case study on its development	CO2	T2:4.3-4
7	A case study on the modern actuators	CO3	T3: 4.2 R2:4.4
8	A case study on development and historical prospective of modern Hydraulic system	CO3	T3: 4.3 R3:3.6
9	Types of aircraft landing gears and development with historical prospective	CO3	T3: 6.1-6.2 R3: 5
10	A case study on aircraft pneumatic system	CO4	T3: 6.4-6
11	Development of modern gas turbine engine used for aircraft	CO4	R2:6.1
12	Head up display- its advantages and development	CO5	T1: 6.3
13	Development of modern fuel tank for fire resistance and bullet proof materials	CO5	T1: 7.1
14	Electronic control Unit – a case study of its development	CO6	T1: 6.5
15	Development of Fly by Wire – a case study	CO6	T1: 7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Development of Fly by Optics in aircraft – a case study	CO 1	R2:7.3
2	Module: I- INTRODUCTION TO AIRCRAFT SYSTEMS	CO 2	T1, T2, T3 R1,R2
3	Module: II - ELECTRICAL SYSTEMS AND AIR CONDITIONING, PRESSURIZING SYSTEMS	CO 3	T1, T2, T3 R1,R2
4	Module: III - HYDRAULIC SYSTEMS AND PNEUMATIC SYSTEMS	CO 4	T1, T2 R1,R2
5	Module: IV- ENGINE CONTROL AND FUEL SYSTEMS	CO 5	T1, T2 R1,R2
DISCUSSION OF QUESTION BANK			
1	Aircraft structural system, Vehicles system, and Mission system.	CO 1	T1, T2
2	Aircraft electrical power system, air conditioning system layout.	CO 2	R4: T1, T2
3	Flight control hydraulic system.	CO 3, 4	T1, R1
4	Engine working system and component.s	CO 5	T2, R2
5	Engine automated control and fuel flow control.	, CO 6	T2, R1, R2

Signature of Course Coordinator **HOD,AE**
Dr.Yagya Dutta Dwivedi, Professor

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**FINITE ELEMENT METHODS**				
Course Code	AAE009				
Program	B.Tech				
Semester	V				
Course Type	CORE				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4		
Course Coordinator	Mr. S Devaraj				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS002	I	Linear Algebra and Ordinary Differential Equations
B.Tech	AAE002	III	Theory of Structures

II COURSE OVERVIEW:

The finite element methods (FEM) 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 Methods	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
0 %	Understand
100 %	Apply
0 %	Analyze

Continuous Internal Assessment (CI):
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:

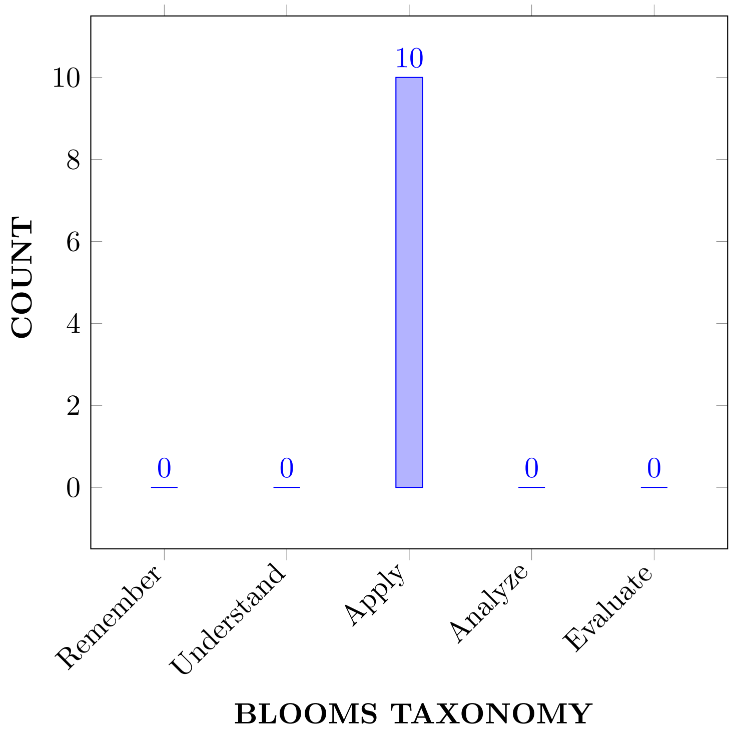
I	The basic concepts of Finite Element methods and its applications to complex engineering problems.
II	The characteristics and selection of different finite elements used in finite element methods.
III	The equilibrium equations and stress-strain relations for different boundary conditions encountered in structural and heat transfer continuum problems.
IV	The application of the FEM technique to dynamic problems and validate the solutions through simulation software for real time applications.

VII COURSE OUTCOMES:

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

CO 1	**Choose** discretization concepts and shape functions of structural members for computing displacements and stresses of the aircraft components.	Apply
CO 2	**Utilize** the shape functions of truss and beam elements for obtaining stiffness matrix and load vector to compute nodal displacement, stresses.	Apply
CO 3	**Identify** the required discreet models of constant strain triangle element for estimating displacement and stress under load conditions.	Apply
CO 4	**Make use of** axi-symmetric modelling concepts to solids of revolution for stress approximation	Apply
CO 5	**Apply** numerical techniques of heat transfer problems to compute the temperature gradients under various thermal boundary conditions	Apply
CO 6	**Develop** the governing equations for the dynamic systems to estimate circular frequency and mode shapes, in correlation with modern tools	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/AAT/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/AAT/SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/AAT/SEE
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	CIE/AAT/SEE
PO 5	**Modern Tool Usage:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	CIE/AAT/SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	3	CIE/AAT/SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

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

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	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, understand the statement and formulate** the global stiffness matrix and load vector for 1D bar element by using **given information** and **develop the solution** for obtaining displacements, stresses and strains in reaching substantiated conclusions by the **interpretation of results.**	7
	PSO 2	**Identify the given problem and formulate** the global stiffness matrix and load vector for 1D bar element by using **given information** and **develop the solution** for obtaining displacements, stresses and strains in reaching substantiated conclusions.	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 shape functions of truss and beam elements, understand the statement** and **formulate** stiffness matrix by using **information** of shape functions of truss and beam elements for **developing** the solution of stresses and nodal displacements in reaching substantiated conclusions by the **interpretation of results.**	7

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 3	**Investigate** the problem of trusses and beams used in bridges, constructions, structures to **ensure the fitness for all aspects of production and maintenance** under applied load condtions that **meet the specific needs with appropriate consdieration for the public health safety and evinronmental considerations**.	5
	PO 10	Able to **communicate desing requirements** of complex trusses and beams structures used in engineering applications with the engineering community and **write effective reports** and **desing documentation** to give and receive clear instructions.	3
	PSO 2	**Identify the shape functions of truss and beam elements** and **formulate** stiffness matrix by using shape functions of truss and beam elements for obtaining the solution of stresses and nodal displacements in reaching substantiated conclusions by the **interpretation of results.**	3
	PSO 3	Make use of **physics for developing** shape functions of truss and beam elements to get stiffness matrix and load vector for calculating nodal displacements and stresses.	2
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	**Identify** the mathematical model, **understand the problem** of two dimensional CST elements for **formulating** stiffness matrix and load vector to **develop** the soultion.	5
	PO 4	**Analyze structures** using CST elements under applied load condtions by using **finite element package** softwares by **interpretation of data to provide valid conclusions.**	5
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.**	5
	PO 3	**Investigate** the problem using axi-symmetric elements to **ensure the fitness for all aspects of production and maintenance** under applied load condtions that **meet the specific needs with appropriate consdieration for the public health safety and evinronmental considerations**.	5
	PSO 2	**Identify the shape functions of axi-symmetric elements** and **formulate** stiffness matrix by using shape functions of axi-symmetric elements for obtaining the solution of stresses and nodal displacements 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.
	PSO 3	Make use of **physics for developing** shape functions of axi-symmetric elements to get stiffness matrix and load vector for calculating nodal displacements and stresses.	2
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.**	5
	PO 4	**Analyze engineering problems** using thermal load condtions by using **finite element package** softwares by **interpretation of data to provide valid conclusions.**	5
	PO 12	Analyze thermal related problems occured in designing components used in engineering applications.	4
CO 6	PO 1	Develop the **engineering concepts** of dynamic system by using **principles of science and mathematics** to solve structural problems.	3
	PO 2	**Identify the dynamic problem, understand the mathematical model and formulate** the mass matrix for 1D bar element and beam element by using **given information** and **develop the solution** for obtaining natural frequencies of dynamic structures in reaching substantiated conclusions by the **interpretation of results.**	7
	PO 3	**Analyze complex engineering porblems** of practical engineering applications by using finite element software packages to **ensure the fitness for all aspects of production and maintenance** under applied load condtions that **meet the specific needs with appropriate consdieration for the public health safety and evinronmental considerations**.	5
	PO 5	Make use of **modern tools, create and analyse** mathematical model problems for finding the mechanical and thermal properties of elements.	1
	PO 10	Able to **communicate desing requirements** of dynamic structures used in engineering applications with the engineering community and **write effective reports** and **desing documentation** to give and receive clear instructions.	3
	PO 12	Analyze the problems of structures used in engineering applications subjected to dynamic loads.	4
	PSO 3	Use of **computational and experimental tools for creating mathematical model by using multi physics** 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	7	-	-	-	-	-	-	-	-	-	-	-	4	-
CO 2	3	7	5	-	-	-	-	-	-	3	-	-	-	3	2
CO 3	3	5	-	5	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	5	5	-	-	-	-	-	-	-	-	-	-	4	2
CO 5	3	7	-	5	-	-	-	-	-	-	-	4	-	-	-
CO 6	3	7	5	-	1	-	-	-	-	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	70	-	-	-	-	-	-	-	-	-	-	-	67	-
CO 2	100	70	50	-	-	-	-	-	-	60	-	-	-	50	50
CO 3	100	50	-	45	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	50	50	-	-	-	-	-	-	-	-	-	-	67	50
CO 5	100	70	-	45	-	-	-	-	-	-	-	50	-	-	-
CO 6	100	70	50	-	100	-	-	-	-	60	-	50	-	-	50

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 2	3	3	2	-	-	-	-	-	-	3	-	-	-	2	2
CO 3	3	2	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	2	-	-	-	-	-	-	-	-	-	-	3	2
CO 5	3	3	-	2	-	-	-	-	-	-	-	2	-	-	-
CO 6	3	3	2	-	3	-	-	-	-	3	-	2	-	-	2
TOTAL	18	16	6	4	3	-	-	-	-	6	-	4	-	8	6
AVERAGE	3	2.7	2	2	3	-	-	-	-	3	-	2	-	2.7	2

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**INTRODUCTION**
	Introduction to Finite Element Method for solving field problems. Stress and Equilibrium. Boundary conditions. Strain - displacement relations. Stress-strain relations for 2-D and3-D elastic problems. One Dimensional Problems: Finite element modeling coordinates and shape functions. Assembly of Global stiffness matrix and load vector. Finite element equations – Treatment of boundary conditions, Quadratic shape functions.
MODULE II	**ANALYSIS OF TRUSSES AND BEAMS**
	Analysis of Trusses Stiffness matrix for plane Truss Elements, stress calculations and problems Analysis of beams: Element stiffness matrix for two nodes, two degrees of freedom per node beam element and simple problems.
MODULE III	**CONTINUUM ELEMENTS**
	Finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions. Estimation of load Vector, stresses; Finite element modeling of Axisymmetric solids subjected to Axisymmetric loading with triangular elements. Two dimensional four nodded isoparametric elements and problems
MODULE IV	**STEADY STATE HEAT TRANSFER ANALYSIS**
	Steady state Heat Transfer Analysis: 1-D Heat conduction of slab 1D fin elements, 2D heat conduction - analysis of thin plates, Analysis of a uniform shaft subjected to torsion.
MODULE V	**DYNAMIC ANALYSIS**
	Dynamic Analysis: Dynamic equations, lumped and consistent mass matrices, eigen Values and Eigen Vectors for a stepped bar, beam; Finite element, formulation to 3D problems in stress analysis, convergence requirements, mesh generation, techniques such as semi-automatic AND fully automatic use of software such as ANSYS, NISA, NASTRAN.

TEXTBOOKS

1. Tirupathi K. Chandrupatla and Ashok D. Belagundu, "Introduction to Finite Elements in Engineering", Pearson, 4th Edition, 2011.
2. S. Rao, "The Finite Element Methods in Engineering", Elsevier, 4th Edition 2009.
3. J. N. Reddy, "An Introduction to Finite Element Methods", McGraw Hill, 4th Edition 2009.

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1. O.C. Zienkowitz, "The Finite Element Method in Engineering Science", McGraw Hill. 4th Edition, 2009.
2. Robert Cook, "Concepts and Applications of Finite Element Analysis", Wiley, 4th Edition, 2010.
3. S.Md.Jalaludeen, "Introduction of Finite Element Analysis" Anuradha publications, 4th Edition, 2010

WEB REFERENCES:

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

COURSE WEB PAGE:

1. https://lms.iare.ac.in/index?route=course/details&course_id=101

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Course Outcomes, Program Outcomes, Course Objectives		
CONTENT DELIVERY (THEORY)			
2	Introduction to Finite Element Method and steps involved in FEM	CO 1	T1:1.5 R1:2.4
3	Finite Element Method for solving field problems	CO 1	T1:1.5 R1:2.4
4	Stress and Equilibrium. Boundary conditions. Strain - displacement relations	CO 1	T1:1.5 R1:2.4
5	One Dimensional Problems: Finite element modeling coordinates	CO 1	T1:1.5 R1:2.4
6	Shape functions, Linear and Quadratic shape functions.	CO 1	T1:1.5 R1:2.4
7	Assembly of Global stiffness matrix and load vector.	CO 1	T1:1.5 R1:2.4
8	Finite element equations – Treatment of boundary conditions	CO 1	T1:1.5 R1:2.4
9	Analysis of Trusses: Stiffness matrix for plane Truss Elements	CO 2	T1:1.5 R1:2.4
10	Stiffness matrix for space Truss Elements	CO 2	T1:1.5 R1:2.4
11	Assembly of stiffness matrix for plane truss element	CO 2	T1:1.5 R1:2.4
12	Assembly of stiffness matrix for space truss element and solving the FEM equation to get the nodal values	CO 2	T1:1.5 R1:2.4
13	Analysis of beams: Element stiffness matrix for two noded, two degrees of freedom per node beam element	CO 2	T1:1.5 R1:2.4
14	Assembly of stiffness matrix for Beam element and solving the FEM equation to get the nodal slope and deflection	CO 2	T1:1.5 R1:2.4
15	Global stiffness matrix and load vector matrix assembly	CO 2	T1:1.5 R1:2.4
16	analysis of beam by using FEM approach for cantilever and simple supported beams for different loading condition	CO 2	T1:1.5 R1:2.4
17	Finite element modeling of two dimensional stress analysis with linear strain triangles	CO 3	T1:1.5 R1:2.4
18	Finite element modeling of two dimensional stress analysis with constant strain triangles	CO 3	T1:1.5 R1:2.4
19	Treatment of boundary conditions. Estimation of load vector and stresses.	CO 3	T1:1.5 R1:2.4
20	shape functions for triangular element	CO 3	T1:1.5 R1:2.4
21	shape functions for quad element	CO 3	T1:1.5 R1:2.4

S.No	Topics to be covered	CO's	Reference T1: 4.1
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	T3:1.5 R1:2.4
2	Problems on ritz methods using minization of potential energy approach	CO 1	T1:1.5 R1:2.4
3	Problems on stepped bar element using elimination and penalty approach	CO 1	T1:1.5 R1:2.4
4	Problems on plane truss element to determine the nodal displacements	CO 2	T1:1.5 R1:2.4
5	Problems on space truss element to determine the nodal displacements	CO 2	T1:1.5 R1:2.4

S.No	Topics to be covered	CO's	Reference T1: 4.1
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 and 3-D elastic problems	CO 1	T1:1.5 R1:2.4
2	Truss and beam stiffness matrix, matrix assembly	CO 2	T1:1.5 R1:2.4
3	2-D and 3-D stress and strain relationships, LST, CST and axisymmetric analysis methods	CO 3, CO 4	T1:1.5 R1:2.4
4	Heat transfer analysis, conduction and convection matix and assembly	CO 5	T1:1.5 R1:2.4
5	lumped mass model, consistent mass model, natural frequency and meshing techniques	CO 6	T1:1.5 R1:2.4
DISCUSSION OF QUESTION BANK			
1	Stress strain relationships, stiffness matrix for one dimensional bar element, quadratic element	CO 1	R2:2.1
2	Truss elements and problems, Beam element and problems	CO 2	T2:7.3
3	Trinagular elements, Axi-symmetric elements and quadrilateral elements	CO 3, CO 4	R2:5.1
4	Heat transfer analysis-fins, one dimenensioanl and two dimensional problems	CO 5	T1:7.5
5	Dynamic analysis of one dimensional and beam elements	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,AE**

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**FLIGHT CONTROLS LABORATORY**					
Course Code	AAE107					
Program	B.Tech					
Semester	V	AE				
Course Type	Core					
Regulation	IARE - R16					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	-	-	-	3	2	
Course Coordinator	Mr. A. Rathan Babu, Assistant Professor					

I COURSE OVERVIEW:

Flight controls laboratory 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 lab introduces the fundamental principles of aerodynamics and propulsion for aircraft performance in classical flying stages and the point of confluence of other disciplines with aeronautical engineering and the gateway to aircraft design.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME002	II	Engineering Mechanics
B.Tech	AAE001	III	Introduction to Aerospace Engineering

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
FLIGHT CONTROLS 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:

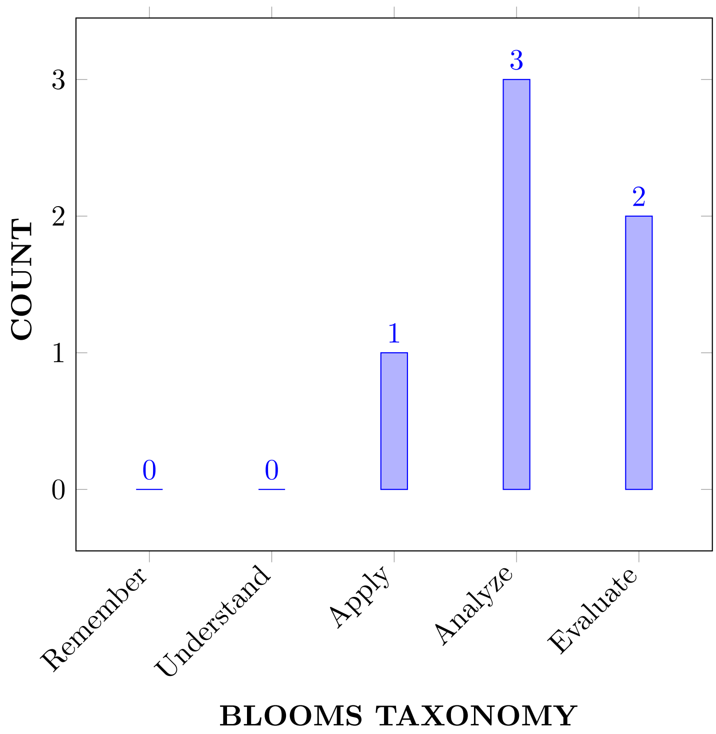
I	Understand the basics simulation of unaccelerated and accelerated level flight for climb and descend.
II	Analyze the takeoff and landing performance and ground roll for different modes of aircraft.
III	Identify the basic controls and maneuver of in complex flight Path.
IV	The aircraft equations of motion to correlate qualitatively with potential applications in aircraft stability in different degrees of freedom

VII COURSE OUTCOMES:

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

CO 1	**Demonstrate** the accelerated and uncelebrated level flight by using MATLAB programming for steady and level flight and climb.	Apply
CO 2	**Analyse** the equations of motion in 1-D and 2-D uncelebrated and accelerated climb by using MATLAB for steady descent and take-off.	Analyze
CO 3	**Estimate** the take-off and velocity and ground roll distance performance using simulator for the Cessna aircraft.	Evaluate
CO 4	**Examine** the operation of disturbed flight to trimmed flight with given mission profile for long and short period modes.	Analyze
CO 5	**Identify** the spin recovery modes and level turn radius by using MATLAB for coordinated level turns of the aircraft.	Analyze
CO 6	**Compare** the barrel roll and maneuverer and simple maneuverer by using simulator for the Cessna aircraft.	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 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	Lab Exercises/CIE/SEE
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	3	Lab Exercises/CIE/SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Lab Exercises/CIE/SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	3	Lab Exercises/CIE/SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	**Justification for mapping (Students will be able to)**	No. of Key Competencies
CO 1	PO 1	Apply the 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
	PO 9	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.	1
	PO 12	Understand the given **problem statement and formulate** the dimensional analysis and similarity parameters for predicting physical parameters that govern aircraft systems in designing prototypes devices	1
CO 2	PO 1	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.	2
	PO 2	Identify the principles associated with heat transfer to **formulate** and calculate the flow field variables **using principles of mathematics, Design and engineering sciences.**	2
	PO 5	Comprehend and write effective reports that are employed during takeoff and landing phases depending upon its mission by developing good communication.	2
	PO 9	Understand fluid flow processes and the corresponding the context of **engineering knowledge related to different methods** of flight systems and analyse the basic parameters influencing the flow by incorporating commercial codes.	1
	PO 12	**Illustrate the performance of aircraft** in rate of decent phase and appropriate conclusions are drawn by communicating effectively to with engineering community.	1
	PSO 2	Develop practical experience in building the real time products, using **industry standard and collaboration technique** in the field of Heat Exchangers.	1
CO 3	PO 1	Understand the given **problem statement and formulate** (complex) engineering problems by modeling and applying corresponding boundary **information and data** in reaching substantiated conclusions by the**interpretation of results.**	2
	PO 2	Identify (knowledge) the performance of aircraft in cruising phase and appropriate conclusions are drawn with the fundamentals of mathematics, science, and engineering fundamentals. .	2

	PO 3	**Understanding** the basic processes to **conduct investigations of complex problems**in the **design, analysis to provide numerical solution** in order to minimize the T.E error.	2
	PO 9	Choose the necessary discretization methods to analyse the stability of fluid system in the aspect of design the problems experimentally and numerically to recognize the significance of them in solving various engineering problems and creating solutions for thermal systems.	2
	PO 10	**Apply the skills** of force system of the aircraft and the development of equations of motion as individual and team work	1
	PO 12	**Illustrate the performance of aircraft** in rate of climb phase and appropriate conclusions are drawn by communicating effectively to with engineering community. .	1
	PSO 2	Develop practical experience in building the real time products, using **industry standard and collaboration technique** in the field of Heat Exchangers.	2
CO 4	PO 1	Select appropriate methods for numerical formulations from the fundamentals of mathematics and engineering **fluid thermal sciences.**	1
	PO 2	**Identify** and Understand the given flight path problem and **formulate**the appropriate technique by using **first principles of mathematics** (Partial differential equations) to get analytical **solutions** in order to**validate results.**	1
	PO 5	**Formulate the problem statement and identify** the suitable finite difference method to obtain substantiated conclusions by the interpretation of results.	1
	PO 9	**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 to provide solutions by analyzing the processes.	2
	PO 12	**Illustrate the performance of aircraft** in decent phase and appropriate conclusions are drawn by communicating effectively to with engineering community.	1
CO 5	PO 1	**Analyse** the different discretization methods for solving thermal problems by using **engineering fundamentals in fluid sciences using mathematical equations** (partial differential equations) to minimise the errors.	2
	PO 3	**Understand the customer (Product) requirement, identify the proper solution** method for thermal equipment's used **in various applications** in the design and **evaluation of outcomes.**	2

	PO 9	Understand the characteristics of various fluid flow processes, understand the corresponding the context of **engineering knowledge related to different methods** to analyse the basic parameters influencing the flow by incorporating commercial flight performance codes.	2
	PO 10	Understand the customer requirement, identify the proper flight performance for **complex thermal systems used in various applications**.	2
	PO 12	**Illustrate the performance of aircraft** in climb phase and appropriate conclusions are drawn by communicating effectively to with engineering community.	1
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
	PO 2	**Knowledge and understanding** the basic processes to **conduct investigations of complex problems**in the **design, analysis to provide numerical solution** in order to minimize the error.	2
	PO 5	Recognize (Knowledge) the characteristics of various fluid flow processes, understand the corresponding the context of **engineering knowledge related to different methods** of flight mechanics and analyse the basic parameters influencing the flow by incorporating commercial codes.	1
	PO 9	Identify the available partial differential equations (analytical methods) for engineering fluid flow problems and apply computer software to provide solutions by analyzing the processes.	1
	PO 10	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.	1
	PO 12	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.	1
	PSO 2	Illustrate the performance of aircraft in cruising phase and appropriate conclusions are drawn by communicating effectively to with engineering community.	2

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

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

XIII ASSESSMENT METHODOLOGY DIRECT:

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

XIV ASSESSMENT METHODOLOGY INDIRECT:

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

XV SYLLABUS:

WEEK I	**SIMULATION OF UNACCELERATED AND ACCELERATED LEVEL FLIGHT**
	Implement the following tasks I. Simulation of steady flight II. Simulation of accelerated level flight at various altitudes
WEEK II	**SIMULATION OF UNACCELERATED AND ACCELERATED CLIMB**
	Implement the following tasks I. Simulation of steady climb. II. Simulation of accelerated climb at various climb rates
WEEK III	**SIMULATION OF UNACCELERATED AND ACCELERATED DESCENT**
	Implement the following tasks I. Simulation of steady descent. II.Simulation of accelerated descent at various descent rates.
WEEK IV	**SIMULATION OF TAKE-OFF PERFORMANCE**

	Implement the following tasks I. Estimation of takeoff velocity for Cessna flight.
WEEK V	**SIMULATION OF LANDING PERFORMANCE**
	Implement the following tasks I. Estimation of ground roll distance for Cessna flight. II.Estimation of total landing distance for Cessna flight.
WEEK VI	**SIMULATION OF CONVENTIONAL FLIGHT PATH**
	Implement the following tasks I.Perform the given mission profiles
WEEK VII	**STABILIZATION OF LONGITUDINAL PERTURBED AIRCRAFT**
	Implement the following tasks I.Perform the operation from disturbed flight to trim flight. II.Perform long period and short period modes.
WEEK VIII	**STABILIZATION OF LATERAL PERTURBED AIRCRAFT**
	Implement the following tasks I. Perform the operation from disturbed flight to trim flight. II.Simulate lateral directional modes.
WEEK IX	**SIMULATION OF SPIN RECOVRY**
	Implement the following tasks I.Perform the operation of spin recovery
WEEK X	**SIMUILATION OF COORDINATED LEVEL TURN**
	Implement the following tasks I.Perform the level turn at given turn rate. II.Perform the level turn at given turn radius.
WEEK XI	**SIMUILATION OF BARREL ROLL MANEUVER**
	Implement the following tasks I. Perform the barrel roll maneuver.
WEEK XII	**SIMULATION OF A COMPLEX FLIGHT PATH**
	Implement the following tasks I. Perform flight simulation for given mission profiles.

Reference Books:

1. Anderson, J.D. Jr., Aircraft Performance and Design, International edition McGraw Hill, 1stEdition, 1999, ISBN: 0-07-001971-1

2. Eshelby, M.E., Aircraft Performance theory and Practice, AIAA Education Series, AIAA, 2nd Edition, 2000, ISBN: 1-56347-398-4

3. McCormick, B.W, Aerodynamics, Aeronautics and Flight Mechanics, John Wiley, 2nd Edition,1995, ISBN: 0-471-57506-2.

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	Simulation of unaccelerated and accelerated level flight.	CO 1	R1: 2.3

2	Simulation of unaccelerated and accelerated climb.	CO 3,CO 4,CO 6	R2: 2.6
3	Simulation of unaccelerated and accelerated descent.	CO 2, CO 3	R1: 2.6
4	Simulation of take-off performance.	CO 3,CO 4,CO 6	R2: 2.7
5	Simulation of landing performance.	CO 3, CO 4	R3: 2.22
6	Simulation of conventional flight path.	CO 3, CO 4	R2: 2.25
7	Stabilization of longitudinal perturbed aircraft.	CO 4	R3: 2.55
8	Stabilization of lateral perturbed aircraft.	CO 3, CO 4	R2: 2.3
9	Simulation of spin recovry.	CO 4,CO 5	R1: 2.6
10	Simuilation of coordinated level turn.	CO 3,CO 4, CO 6	r2: 2.8
11	Simuilation of barrel roll maneuver.	CO 3,CO 6	R1:2.18
12	Simulation of a complex flight path.	CO 3,CO 6	R4:2.22

XVII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Maximum and minimum speeds in level flight.
2	Climb and descent technique generalized performance.
3	Lateral maneuvers- turn performance- turn rates.
4	akeoff performance safety factors.
5	The minimum drag speed.

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	**UNMANNED AIR VEHICLES**				
Course Code	AAE506				
Program	B.Tech				
Semester	Seven				
Course Type	Elective				
Regulation	R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr.Praveen Kumar Balguri				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME003	III	Thermodynamics
B.Tech	AAE003	III	Fluid Mechanics and Hydraulics

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). 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
%	Remember
55	Understand
30	Apply
15	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:

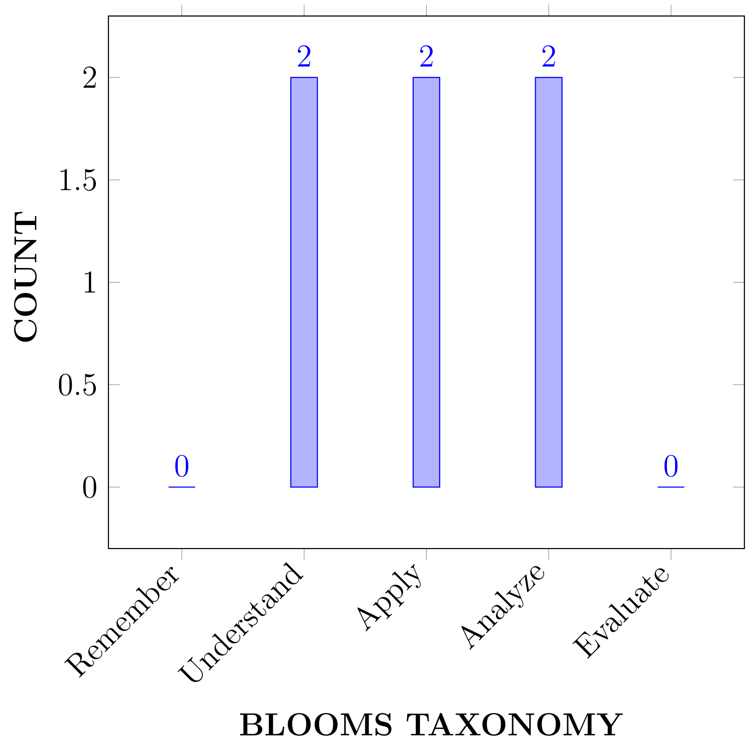
I	The major subsystems and the fundamental design phases of Unmanned Air Vehicle Systems (UAS).
II	The basic drags and airframe configurations of Unmanned Air Vehicles (UAVs).
III	The various communication media and navigation systems of UAVs.
IV	The different techniques used to achieve the control and stability of UAVs.

VII COURSE OUTCOMES:

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

CO 1	**Demonstrate** the knowledge of major sub-systems and basic design concepts for the development of unmanned air vehicle systems.	Understand
CO 2	**Illustrate** the different types of airframe configurations available for unmanned air vehicle systems.	Understand
CO 3	**Analyze** the attributes, performance, design issues, and compromises of different types of aircraft for UAV systems to select suitable aircraft.	Analyze
CO 4	**Select** a suitable power-plant based on power generation systems for the given mission requirement.	Apply
CO 5	**Identify** the appropriate communication and navigation systems for the UAVs as per the role requirements.	Apply
CO 6	**Categorize** the different techniques used to achieve the control and stability of UAV systems.	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.

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recognize the functions of each major sub-systems, scaling effects, package density, basic aerodynamics, and structures concepts **(scientific principles and own engineering discipline)** of the unmanned air vehicle systems to the solution of complex UAV engineering design problems by applying **Science and Own and / or other engineering disciplines knowledge**.	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 different types of airframe configurations **(principles of mathematics and own engineering discipline)** to select suitable airframe during the conceptual phase as per the given mission requirement.	2
	PO 2	Identify the mission requirement **(problem identification)**, define the required airframe performance parameters **(problem statement and system definition)** using the knowledge of various airframes **(information and data collection/review of literature)**, develop the high performance airframe **(design, and reaching the substantial solution)** as per the mission requirements.	5
CO 3	PO 1	Apply the knowledge of attributes, performance, design issues and compromises of different types of aircraft **(principles of mathematics and own engineering discipline)** to select suitable airframe during the preliminary phase as per the given mission requirement.	2
	PO 2	Identify the problems **(Identify)**the attributes, performance, design issues, review research literature **(information and data collection)**, and analyze complex engineering problems, design**(design)** reaching suitable aircraft **(solution)**.	4
	PO 4	Use the knowledge of differentdesign issues **(knowledge of characteristics of particular processes)** in selecting the suitable aircaft **(understanding of contexts in which engineering knowledge can be applied)**.	2
CO 4	PO 1	Apply the knowledge of different power generation systems includes an energy source, a means of convertingthat energy into mechanical energy and a means of converting that into a lift or thrust force **(mathematical and engineering principles)** during the selection of a suitable power-plant for the given role requirement.	2
	PO 2	Define the mission requirement **(problem statement and system definition)** and apply the knowledge of different types of powerplants available **(information and data collection)** for aircraft to select the suitable one **(solution development)** during the conceptual phase.	3
CO 5	PO 1	Identify the appropriate communication and navigation systems for the UAVs as per the role requirements by applying the knowledge of communication and navigation systems **(principles of mathematics and other engineering discipline)**.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 4	Use the knowledge of communication and navigation systems **(knowledge of characteristics of particular products)** in selecting the suitable system **(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 communication and navigation systems in aeronautical systems to provide the communication and navigation system **(propulsion)** for UAS.	1
CO 6	PO 1	Apply the knowledge of **mathematics, engineering** fundamentals to justify the need of control and stability of UAV systems and means of achieving the control and stability of UAV systems	2
	PO 2	Identify the problems **(Identify)** of control and stability of UAV systems , review research literature **(information and data collection)**, and analyze complex engineering problems, design**(design)** reaching suitable control and stability of UAV systems **(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 ≤ 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	-	-	-	-	-	-	-	-	-	-	-	-	-	
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	**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

WEB REFERENCES:

1. https://nptel.ac.in/courses/101104073

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	Program Outcomes, Program Educational Outcomes, Course Objectives and Outcomes, Blooms Taxonomy, Course Articulation matrix		
	CONTENT DELIVERY (THEORY)		
1	Introduction to UAVs.	CO 1	T1-1.1 , 1.3, 1.4, 1.7
2	The systemic basis of UAS-system composition	CO 1	T1- 1.2,1.8,1.9
3	The systemic basis of UAS-system composition	CO 1	T1- 1.15, 1.16
4	Conceptual phase; Preliminary design	CO 1	T1- 1.6
5	Selection of the system	CO 1	T1- 2.2, 2.6
6	Some applications of UAS	CO 1	R1-2.6, 2.10
7	Lift-induced Drag; Parasitic Drag	CO 2	T1-3.2, 3.3
8	Rotary-wing aerodynamics	CO 2	T1-3.5
9	Response to air turbulence	CO 2	T1-2.13, 2.14 and 2.16
10	Airframe configurations	CO 2	R2-2.15
11	Airframe configurations	CO 2	R2-3.9, 3.6

12	Scale effects; Packaging density, Aerodynamics; Structures and mechanisms	CO 2	T1-6.1, 6.3
13	Selection of power-plants	CO 4	T1-6.2, 6.3
14	Modular construction; Ancillary equipment	CO 2	T1-6.5, 6.6
15	Long-endurance, long-range role aircraft	CO 3	R1-6.7, 6.8
16	Long-endurance, long-range role aircraft	CO 3	T1-7.1
17	Medium-range, tactical aircraft	CO 3	T1- 7.2, 7.3 and 7.4
18	Medium-range, tactical aircraft	CO 3	T1- 7.9
19	Close-range /battlefield aircraft	CO 3	T2-7.9, 7.10
20	Close-range /battlefield aircraft	CO 3	T1- 7.11
21	Close-range /battlefield aircraft	CO 3	T1- 10.1, 10.2, 10.3
22	MUAV types	CO 3	T1-10.4, 10.5
23	MAVs and NAVs types	CO 3	R2-2.15
24	MAVs and NAVs types	CO 3	R2-3.9, 3.6
25	MAVs and NAVs types	CO 3	T2-6.1, 6.3
26	UCAV; Novel hybrid aircraft configurations; Research UAV	CO 3	T1-6.2, 6.3
27	Communication media; Radio communication	CO 5	T1-6.5, 6.6
28	Radio communication	CO 5	R1-6.7, 6.8
29	Radio communication , Mid-air collision (MAC) avoidance; communications data rate and bandwidth usage	CO 5	T1-7.1
30	Antenna Types	CO 5	T1- 7.2, 7.3 and 7.4
31	NAVSTAR Global Positioning System (GPS)	CO5	T1- 7.9
32	TACAN - LORAN C - Inertial Navigation	CO 5	T1-7.9, 7.10
33	Radio Tracking - Way-point Navigation	CO 5	T1- 7.11
34	HTOL Aircraft	CO 6	T1- 10.1, 10.2, 10.3
35	HTOL Aircraft	CO 6	T1-10.4, 10.5
36	HTOL Aircraft, Helicopters	CO 6	T1-6.1, 6.3
37	Helicopters	CO 6	T1-6.2, 6.3
38	Helicopters	CO 6	T1-6.5, 6.6
39	Convertible Rotor Aircraft, Payload Control ,Sensors	CO 6	R1-6.7, 6.8
40	Payload Control, Sensors, Autonomy.	CO 6	T1-7.1
PROBLEM SOLVING/ CASE STUDIES			
41	Explain the different roles where UAVs can perform better than manned aircrafts, discuss them in detail?	CO 1	
42	Explain the different means of navigation (or fall-back options) when GPS system is blocked?	CO1	
43	Discuss the different design phases of most aircraft based systems.	CO 1	
44	Describe the two main causes for an aircraft to have a high response to atmospheric turbulence, discuss by considering wing loading?	CO 2	

45	Identify the importance of 'Airframe configuration' in design of UAVs?	CO 3	
46	Identify the importance of undercarriage for UAVs and discuss the design parameters.	CO 3	
47	How modular construction concept does helps in the design of UAVs.	CO 3	
48	Classify the three main concerns of the Long-endurance, Long-range Role UAV designer, discuss in detail with the necessary diagram?	CO 3	
49	Identify the need for close-range UAV systems, discuss few design aspects.	CO 3	
50	Explain different types of TUAVs and give their applications	CO 3	
51	Why the communication is of paramount importance in UAS operations? Discuss the possible reasons for loss of communication during the operations.	CO 4	
52	Explain the important points in selection of power-plants for UAVs with the help of power-generation systems.	CO 4	
53	What are the different ways in which UAV may be vulnerable and discuss how can they be reduced?	CO 5	
54	Explain the different sensors used to measure airspeed and height of UAV.	CO 6	
55	Compare the stability and control of SMR with fixed- wing aircraft.	CO 6	
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Unmanned aircraft systems, categories, applications	CO 1, CO 2	
57	Aerodynamics and airframe configurations of UAVs	CO 3	
58	Characteristics of UAS aircraft types	CO 3	
59	Communications and navigation systems of UAS	CO 5	
60	Control and stability of various UAVs	CO 6	
DISCUSSION OF QUESTION BANK			
61	UAS-system composition, Design phases	CO 1	
62	Airframe configurations	CO 2	
63	Characteristics of aircraft types	CO 3	
64	Communications and navigation	CO 5	
65	Control and stability	CO 6	

Signature of Course Coordinator **HOD,AE**

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**AEROSPACE STRUCTURAL DYNAMICS LABORATORY**				
Course Code	AAE113				
Program	B.Tech				
Semester	V	AE			
Course Type	CORE				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Dr.A. Aravind Rajan, Associate Professor				

I COURSE OVERVIEW:

Theory of machines is defined as that branch of engineering science, which deals with the study of relative motion between various parts of a machine and forces which acts on them. The knowledge is very essential for engineer in designing Various parts of a machine.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AMEB11	IV	Materials and Mechanics of Solids	1.5

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
AEROSPACE 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 HOW PROGRAM OUTCOMES ARE ASSESSED:

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

PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises/CIA/SEE
PO 9	**Individual and team work:**Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Lab Exercises/CIA/SEE

3 = High; 2 = Medium; 1 = Low

VII HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

VIII COURSE OBJECTIVES:

The students will try to learn:

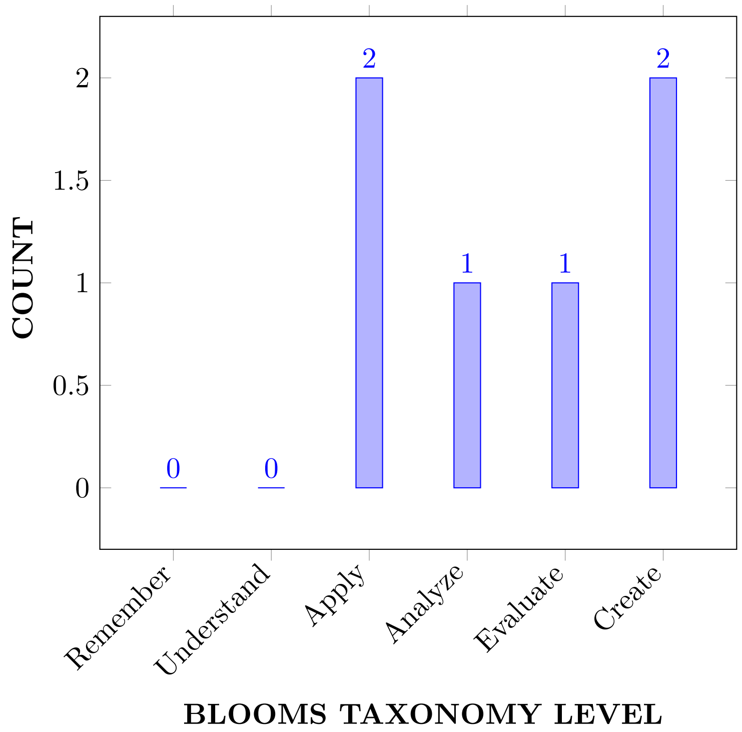
I	The Importance of theory of machines and mechanism involved in the day-to-day life, and study of basic mechanisms and inversion mechanisms to form a machine.
II	The information related design and analysis of mechanisms for a specific type of motion in a machine.
III	The developmental use of rigid bodies motions and forces for transmission system, machine kinematics.

IX COURSE OUTCOMES:

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

CO1	**Identify** the gyroscopic effect for the real time applications of ships, aero planes .	Apply
CO2	**Examine** the life expectancy for ball bearing and their real time application.	Analyze
CO3	**Select** the appropriate journal bearing for balancing of machine components such as shafts.	Apply
CO4	**Build** out the inversion mechanism for 4-bar mechanism to form different mechanical compoenents.	Evaluate
CO5	**Design** the shafts material for calculate the critical speed of shafts	Create
CO6	**Choose** the balancing techniques for effective balancing of machines and structures.	Create

COURSE COURSE KNOWLEDGE COMPETENCY LEVEL:



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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and engineering fundamentals	3
	PO 2	Understand the given **problem statement and apply data validation techniques to solve** (complex) specific engineering problems related to making of governors	2
	PO 6	Recall (knowledge) the different engineering design standards for safe operation in designing governors	3
	PO 9	Understand the given problem and **work either individually or in a group** to design a good and safe bearing / governor that shall be used for different mechanisms	3
	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments	2

	PSO 2	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 2	PO 1	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	3
	PO 2	Understand the given **problem statement and apply data validation techniques to solve** (complex) specific engineering problems related to making of governors	2
	PO 6	Recall (knowledge) the **different engineering design standards** for safe operation in designing governors	3
	PO 9	Understand the given problem and **work either individually or in a group** to design a good and safe bearing / governor that shall be used for different mechanisms	3
	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments	2
	PSO 2	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 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	3
	PO 2	Understand the given **problem statement and apply data validation techniques to solve** (complex) specific engineering problems related to making of governors	2
	PO 3	Understand the given problem (complex) to **come up with innovative and effective solution** specific engineering problems related to making of governors	3
	PO 6	Recall (knowledge) the **different engineering design standards** for safe operation in designing governors	3
	PO 9	Understand the given problem and **work either individually or in a group** to design a good and safe bearing / governor that shall be used for different mechanisms	3
	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments	2
	PSO 2	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2

CO 4	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	3
	PO 2	Understand the given **problem statement and apply data validation techniques to solve** (complex) specific engineering problems related to making of governors	2
	PO 3	Understand the given problem (complex) to **come up with innovative and effective solution** specific engineering problems related to making of governors	2
	PO 6	Recall (knowledge) the **different engineering design standards** for safe operation in designing governors	3
	PO 9	Understand the given problem and **work either individually or in a group** to design a good and safe bearing / governor that shall be used for different mechanisms	3
	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments	2
	PSO 2	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	3
CO 5	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
	PO 3	Understand the given problem (complex) to **come up with innovative and effective solution** specific engineering problems related to making of governors	3
	PO 6	Recall (knowledge) the **different engineering design standards** for safe operation in designing governors	3
	PO 9	Understand the given problem and **work either individually or in a group** to design a good and safe bearing / governor that shall be used for different mechanisms	3
	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments	2
	PSO 2	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	3

CO 6	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	3
	PO 2	Understand the given **problem statement and apply data validation techniques to solve** (complex) specific engineering problems related to making of governors	2
	PO 6	Recall (knowledge) the different engineering design standards for safe operation in designing governors	3
	PO 9	Understand the given problem and **work either individually or in a group** to design a good and safe bearing / governor that shall be used for different mechanisms	3
	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments	2
	PSO 2	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2

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 6	PO 9	PO 10	PSO 2
CO 1	3	2		3	3	2	2
CO 2	3	2		3	3	2	2
CO 3	3	2	3	3	3	2	2
CO 4	3	2	2	3	3	2	3
CO 5	3	2	3	3	3	2	3
CO 6	3	2		3	3	2	2

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1, PO 2	SEE Exams	PO 1, PO 2, PO 5, PO 9 PSO 3	Seminars	-
Laboratory Practices	PO 1, PO 2, PO 5, PO 9	Student Viva	PO 1,PO 2, PO 5,PO 9	Certification	-
Assignments	PO 5, PO 9, PO 3	Mini projects	-		

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK 1	**GOVERNOR**
	To study the function of a Governor
WEEK 2	**GYROSCOPE**
	To determine the Gyroscope couple.
WEEK 3	**STATIC FORCE ANALYSIS**
	To draw free body diagram and determine forces under static condition.
WEEK 4	**DYNAMIC FORCE ANALYSIS**
	To draw free body diagram and determine forces under dynamic condition.
WEEK 5	**BALANCING**
	To determine balancing forces and reciprocating masses.
WEEK 6	**JOURNAL BEARING**
	To determine the bearing life.
WEEK 7	**UNIVERSAL VIBRATION**
	To determine the longitudinal and transfer vibration.
WEEK 8	**WHIRLING OF SHAFT**
	To determine critical speed of a shaft.
WEEK 9	**MECHANISMS**
	To design various mechanism and their inversions.
WEEK 10	**DIFFERENTIAL GEAR BOX**
	To study automobile differential gear box.
WEEK 11	**Indexing**
	To study various intermittent mechanism.
WEEK 12	**BEYOND SYLLABUS**
	To study various intermittent mechanism
WEEK 13	**EXAMINATIONS**

TEXTBOOKS

1. Thomas Bevan, “Theory of Machines”, Pearson Education, 3rd Edition, 2009.
2. . S.S Ratan, “Theory of Machines”, Tata McGraw-Hill, 4th Edition, 2014.

REFERENCE BOOKS:

1. J. S. Rao, R.V. Dukkipati, “Mechanism and Machine Theory”, New Age Publication, 1st Edition, 2013.

2. Uiker, Penock, Shigley, "Theory of Machines and Mechanisms", Oxford University Press, 4th Edition, 2013.

3. R.S. Khurmi, Guptha, "Theory of Machines", S.Chand & Co, New Delhi, 14th Edition, 2013.

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Governor	CO1, CO 5	T1:2.1.5 T2:2.3
2	Gyroscope	CO1, CO 5	T2:2.1.5 R1:2.6
3	Static Force Analysis	CO 1, CO 4, CO 5, CO 6	T1:2.6 R3:3.6.5
4	Dynamic Force Analysis	CO 2, CO 6	T2:2.7 R2:2.18
5	Balancing	CO 2, CO 6	T2:2.22 R3:3.1.1
6	Journal Bearing	CO 2, CO 6	T1:2.5.1 T2:2.25
7	Universal Vibration	CO 3, CO 6	T2:2.26 R3:2.55
8	Whirling of Shaft	CO 3, CO 6	T2:2.3 R3:2.6
9	Mechanisms	CO 3, CO 6	T2:2.3 R1:2.6
10	Differential Gear Box	CO 4, CO 6	T1:2.6
11	Indexing	CO 4, CO 6	T2:2.7 R1:2.18

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design of flywheel for I.C engine and punch press.
2	Design of journal bearing using different lubrication oils and different speeds.
3	Design of ball bearing for different loads and estimation of life.
4	Design of differential gear box for automobile I.C Engine.
5	Design of inversion four bar mechanism.

Prepared by: **HOD,ME**

Ms.V.Lakshmi Prasanna,, Assistant professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**COMPUTER AIDED MANUFACTURING (CAM) LABORATORY**				
Course Code	AAE110				
Program	B.Tech				
Semester	VI	AE			
Course Type	CORE				
Regulation	R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Dr. D Govardhan, Professor				

I COURSE OVERVIEW:

Computer-aided manufacturing (CAM) is a manufacturing process that uses computer software and machinery in manufacturing processes for production of aircraft components, assemblies and final product to meet the global competition. It imposes the knowledge of latest manufacturing techniques using CNC/DNC Machines centres with different CNC programming methods, Manufacturing processes and Group Technologies. It also deals with 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.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC02	II	Manufacturing PracticeAircraft Materials and Production Laboratory
B.Tech	AAE105	IV	Aircraft Materials and Production Laboratory

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
COMPUTER AIDED MANUFACTURING 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	Gain knowledge about software equipment, tools and machines associated with computer aided manufacturing.
II	Execute simple operations using computer numerical control codes.

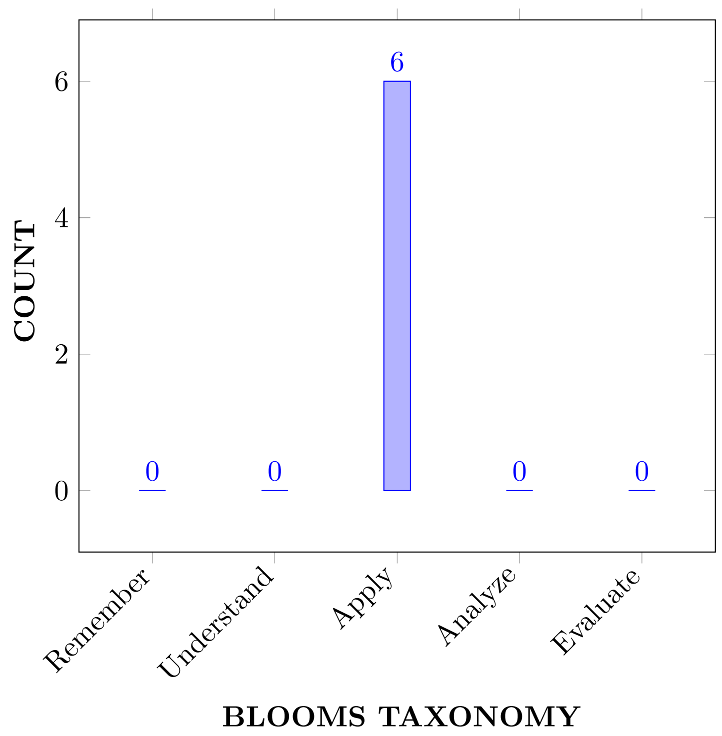
III	Identify parameters and tools suitable for manufacturing a component on computer numerical control machines .
IV	Create a computer aided manufacturing (CAM) model and generate the machining codes automatically using the CAM system .

VII COURSE OUTCOMES:

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

CO 1	**Make use of** suitable CNC machines based on features and functions for producing aircraft components. .	Apply
CO 2	**Identify** the type of operations performed using CNC machine tools for completion of components in time with minimum cost	Apply
CO 3	**Select** the suitable operations performed using CNC milling machine for producing accurate aircraft components.	Apply
CO 4	**Experiment** the cylindrical grinding operation using CNC cylindrical grinding machine for better surface finished components.	Apply
CO 5	**Select** the Laser cutting machine for aerofoil profile cutting with dimensional and geometrical accuracy.	Apply
CO 6	**Apply** the rapid drilling operation using Electrical Discharge machine for improving rate of productivity.	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 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	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	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 12	**Life-Long Learning: :**Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of modern computer tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2	Lab 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 2	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 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 12	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 3	Apply (knowledge) of casting and welding process in solving aircraft designing problems by applying the principles of science and Engineering .	1
CO 2	PO 1	Identify (knowledge) suitable methods involved during welding for error free components by applying **Scientific principles and methodology**	2
	PO 2	identifying the microstructure (understanding) their importance and **application** (apply) in industries by applying the **principles of science and Engineering**	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 12	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 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 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	2
	PO 2	identifying the microstructure (understanding) their importance and **application** (apply) in industries by applying the **principles of science and Engineering**	2
	PO 6	Knowledge and understanding of different welding techniques and **economic context of engineering processes**	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 12	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 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 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 2	identifying the microstructure (understanding) their importance and **application** (apply) in industries by applying the **principles of science and Engineering**	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 12	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 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 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 2	identifying the microstructure (understanding) their importance and **application** (apply) in industries by applying the **principles of science and Engineering**	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 12	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 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 6	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 2	identifying the microstructure (understanding) their importance and **application** (apply) in industries by applying the **principles of science and Engineering**	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 12	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 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

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 6	PO 9	PO 12	PSO 3
CO 1	2	2	2	3	2	2
CO 2	2	2	2	3	2	2
CO 3	2	2	2	3	2	2
CO 4	2	2	2	3	2	2
CO 5	2	2	2	3	2	2
CO 6	2	2	2	3	2	2

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1, PO 2, PSO 3	SEE Exams	PO 1,PO 2 PO 9, PSO 3	Seminars	-
Laboratory Practices	PO 1,PO 6, PO 12, PSO 3	Student Viva	PO 1, PO 9 ,PO 12	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**INTRODUCTION TO 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.
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. K.L. Narayana, P. Kannaiah, ―Production Drawing‖, New Age publishers, 3 rd Edition, 2009.
2. GouthamPohit, GouthamGhosh, ―Machine Drawing with Auto CAD‖, Pearson, 1 st Edition, 2004.
3. James D. Meadows, ―Geometric Dimensioning and Tolerancing‖, CRC Press, 1 st Edition, 1995.

WEB REFERENCE

1. https://mech.iitm.ac.in/Production

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**
Dr. D Govardhan, Professor

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**SPACE PROPULSION**				
Course Code	AAE012				
Program	B.Tech				
Semester	VI				
Course Type	Core				
Regulation	R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. Gooty Rohan, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME003	III	Thermodynamics
B.Tech	AAE007	IV	Aircraft Propulsion

II COURSE OVERVIEW:

An aerospace propulsion system is a device that generates forces to push the aerospace vehicles forward. This course discusses about the various Aerospace propulsive devices in micro level, it includes an overview of different types of propulsive system present in aircraftsand rockets such as turbojet, turboprop, turbofan, IC engine, solid propellant, hybrid propellant and liquid propellant engines. Along with that design and analysis will be discussed on the various parameters and components present in aerospace propulsive system.

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). 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
16.6%	Understand
66.6%	Apply
16.6 %	Analyze
-%	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	Evaluate various space missions, parameters to be considered for designing trajectories and rocket mission profiles.
II	Understand the fundamentals of chemical rocket propulsion, types of igniters and performance considerations of rockets.
III	Discuss the working principle of solid and liquid propellant rockets and gain basic knowledge of hybrid rocket propulsion.

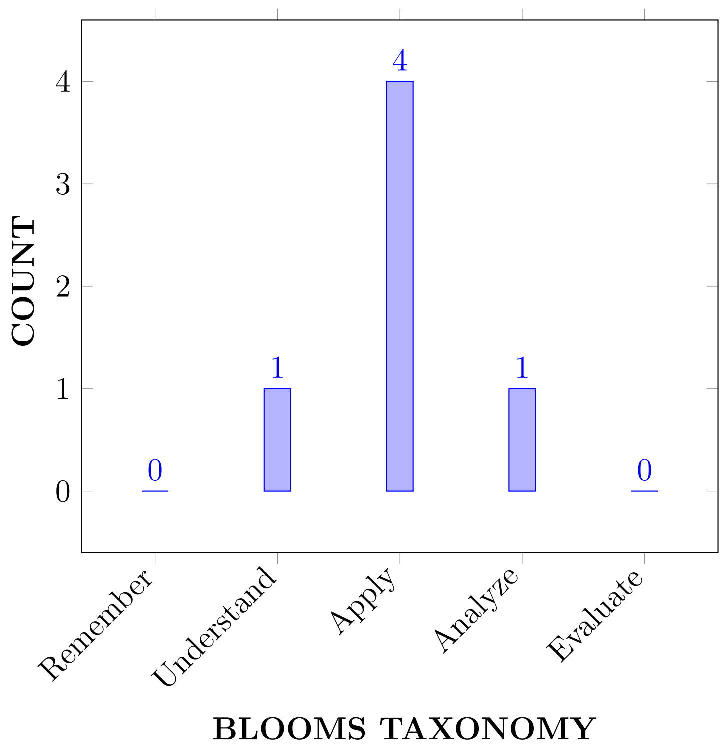
IV	Illustrate electric propulsion techniques, ion and nuclear rocket and the performances of different advanced propulsion systems.

VII COURSE OUTCOMES:

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

CO 1	**Explain** the different types of air-breathing engines using the by using Brayton cycle for selecting the suitable engine to an aircraft.	Understand
CO 2	**Determine** the performance parameters that will influene the air-breathing engines by using parameters like SFC, Thrust, Efficiencies equation for improving the range and endurance of the aircraft.	Apply
CO 3	**Select** the functions and geometrical parameters of different types of inlets, nozzles, combustors and afterburners using aerodynamic principles for selecting of suitable design as per the engine specification.	Apply
CO 4	**Make a use of** velocity triangle method to simplify the performance instability of the compressor and turbine blades for increasing the efficiency of the engine.	Apply
CO 5	**Utilize the** working principles of solid and hybrid rocket motors using Newtons second law of equilibrium for smplifying the limitations and performances level of rocket engine.	Apply
CO 6	**Distinguish** the different propellant feed system and injectors by using equations for thrust vector control for selecting the suitable component in rocket engine.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

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

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	Utilize the knowledge of **mathematics, science and Engineering fundamentals** of rocket engines to simplify the difficult engineering problems.	2
	PO 2	**Identify and formulate** the suitable operating principles to solve the different types of the complex rocket engine problems.	2
	PO 3	**Design and develop** a solution by using engineering principles to simplify the basic orbital equations.	2
	PSO 3	Understand the the operational parameters rocket propulsion system by **using the governing equation** for building the **career path towards startup and employability**.	2
CO 2	PO 1	Analyze the performance parameters of rocket propulsion and their components by applying the suitable engineering knowledge **mathematics, science and engineering fundamentals.**	2
	PO 2	**Identify and formulate** the complex engineering problems by using suitable working principles of rocket engines.	2
	PO 3	**Design and develop** a solution by using engineering principles to simplify the complex problems on rocket propulsive system.	2
	PSO 3	**Make a use of multi physics** to understand the operation procedure of orbital transfering technique for building the career path towards startup and employability.	2
CO 3	PO 1	Understand the fundamentals of rocket propulsion using**mathematical principles and engineering fundamentals** to simplify the performance parameters of rocket engine..	2
	PO 2	Identify the formula to simplify the specific impulse of rocket engine by using suitable **mathematics and engineering knowledge.**	2
	PO 3	**Design solution for complex engineering problems** using engineering principles to design the grain geometry of an solid rocket propulsive system.	2
	PSO 3	Understand the the operational parameters solid rocket propulsion system by **using the governing equation** for building the **career path towards startup and employability**.	2
CO 4	PO 1	Apply the knowledge of various performance parameters of liquid rocket engine **mathematics, science and engineering fundamentals.** for selecting the suitable design.	2

Course Outcomes	**PO'S PSO'S**	**Justification for mapping (Students will be able to)**	**No. of Key competencies matched.**
	PO 2	Choose the suitable working principles of the liquid propulsive system by using **defining, identifying, and formulating.** to solve the complex problems.	2
	PO 3	Make a use of the concepts of liquid rocket propulsion systems to simplify the complex problems for **establishing the innovative design.**	2
	PSO 3	**Make a use of multi physics** to understand the operation procedure of liquid propulsion system for building the career path towards startup and employability.	2
CO 5	PO 1	Recognize the various working principles, **mathematics, science and Engineering fundamentals.** of the hybrid rocket motor to identify the performance characteristics.	2
	PO 2	**Identify and formulate** the various working principles of rocket propulsive system (solid andhybrid) to identify the limitations and performance level.	2
	PO 3	Simplify the performance parameters of hybrid rocket motor to identify **the solution for complex problems.**	2
	PSO 3	Understand the the operational parameters hybrid rocket propulsion system by **using the governing equation** for building the **career path towards startup and employability**.	2
CO 6	PO 1	Evaluate the different propellant feed and injector systems present in electrical propulsive system using **mathematics, science and engineering fundamentals** .	2
	PO 2	Analyze the different propellant feed and injector systems in the electrical propellant rocket motor **identifying, formulating, analyzing** to select the right combination.	2
	PO 3	Analyse the the engineering principles **to simplify the complex problems** on nuclear propellant feed and injector system to **establish the innovative design.**	2
	PSO 3	**Make a use of multi physics** to understand the operation procedure of electric rocket propulsion system for building the career path towards startup and employability.	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	2	-	-	-	-	-	-	-	-	-	-	-	2
CO 2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	2
CO 3	2	2	2	-	-	-	-	-	-	-	-	-	-	-	2
CO 4	2	2	2	-	-	-	-	-	-	-	-	-	-	-	2
CO 5	2	2	2	-	-	-	-	-	-	-	-	-	-	-	2
CO 6	2	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	66.6	20	20	-	-	-	-	-	-	-	-	-	-	-	100
CO 2	66.6	20	20	-	-	-	-	-	-	-	-	-	-	-	100
CO 3	66.6	20	20	-	-	-	-	-	-	-	-	-	-	-	100
CO 4	66.6	20	20	-	-	-	-	-	-	-	-	-	-	-	100
CO 5	66.6	20	20	-	-	-	-	-	-	-	-	-	-	-	100
CO 6	66.6	20	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
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	-	-	-	-	-	-	-	-	-	-	-	3
CO 2	3	1	1	-	-	-	-	-	-	-	-	-	-	-	3
CO 3	3	1	1	-	-	-	-	-	-	-	-	-	-	-	3
CO 4	3	1	1	-	-	-	-	-	-	-	-	-	-	-	3
CO 5	3	1	1	-	-	-	-	-	-	-	-	-	-	-	3
CO 6	3	1	1	-	-	-	-	-	-	-	-	-	-	-	3
TOTAL	18	6	6	-	-	-	-	-	-	-	-	-	-	-	18
AVERAGE	3	1	1	-	-	-	-	-	-	-	-	-	-	-	3

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**PRINCIPLES OF 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	Discussuion of OBE and its importance		
CONTENT DELIVERY (THEORY)			
1	Classification, operational envelopes; Description and function of gas generator, turbojet, turbofan	CO-1	T1-2.2, 2.6
2	Classification, operational envelopes; Description and function of turboprop, turbo shaft, ramjet,	CO-1	T1-2.2, 2.6
3	Engine thrust, takeoff thrust, installed thrust, thrust equation	CO-1	R1-2.6, 2.10
4	Scramjet, turbojet/ramjet combined cycle engine	CO-1	R1-2.6, 2.10
5	Engine performance parameters, specific thrust, specific fuel consumption	CO-1	T1-3.2, 3.3
6	Engine performance parameters specific impulse, thermal efficiency, propulsive efficiency	CO-2	T1-3.2, 3.3
7	Aircraft engine cycle analysis.	CO-2	T1-3.5
8	Engine overall efficiency and its impact on aircraft range and endurance	CO-2	T1-3.5

9	Performance analysis for turbojet, turbojet with afterburner	CO-2	T1-2.13, 2.14 and 2.16
10	Performance analysis for turbofan engine, turboprop engine.	CO-2	T1-2.13, 2.14 and 2.16
11	Subsonic inlets: Function, design variables, operating conditions	CO-3	T2-2.15
12	Subsonic inlets: inlet performance, performance parameters	CO-3	T2-2.15
13	Supersonic inlets: Compression process, types, construction,	CO-3	T1-3.9, 3.6
14	Supersonic inlets: losses, performance characteristics;	CO-3	T1-3.9, 3.6
15	Exhaust nozzles: primary nozzle, fan nozzle, converging nozzle, converging-diverging nozzle.	CO-3	R1-2.3, T2-6.1, 6.3
16	Exhaust nozzles: variable nozzle, and performance maps, thrust reversers and thrust vectoring.	CO-3	R1-2.3, T2-6.1, 6.3
17	Combustors and Afterburners: Geometries, flame stability	CO-3	T1-6.2, 6.3
18	Combustors and Afterburners: Ignition and engine starting, adiabatic flame temperature, pressure losses, performance maps, fuel types and properties.	CO-3	T1-2.2, 2.6
19	Axial flow Compressors: cascade aerodynamics, aerodynamic forces on compressor blades,	CO-4	R1-2.6, 2.10
20	Axial flow Compressors: Geometry, definition of flow angles, stage parameters.	CO-4	R1-2.6, 2.10
21	Rotor frames of reference, compressor performance maps, velocity polygons or triangles	CO-4	T1-3.2, 3.3
22	Stator frames of reference, compressor performance maps, velocity polygons or triangles	CO-4	T1-3.2, 3.3
23	Single stage energy analysis, compressor instability, stall and surge.	CO-4	T1-35
24	Axial Flow Turbines: Geometry, configuration, comparison with axial flow compressors,	CO-4	T1-35
25	Velocity polygons or triangles, single stage energy analysis, performance maps, thermal limits of blades and vanes	CO-4	T1-3.6, 3.8
26	Turbine blade cooling, blade and vane materials, blade and vane manufacture.	CO-5	T1-3.6, 3.8
27	Background description: Classification of rocket propulsion systems	CO-5	T2:7.22
28	Performance of an ideal rocket, rocket thrust equation	CO-5	T2:7.22
29	Total and specific impulse, effective exhaust velocity	CO-5	T2:4.2
30	Rocket efficiencies, characteristic velocity, thrust coefficient	CO-5	T2:4.2
31	Description of solid propellant rocket motor, solid propellant grain configurations.	CO-5	R2, 3.0, T2:12.2

32	Solid propellant rocket motor, homogeneous propellant, heterogeneous or composite propellant	CO-5	R2, 3.0, T2:12.2
33	Different grain cross sections, propellant burning rate, combustion of solid propellants, physical and chemical processes	CO-5	T2:11.3
34	Solid propellant rocket motor Ignition process, combustion instability	CO-5	R2:15.0
35	Hybrid propellant rockets: Hybrid rocket operation and hybrid rocket characteristics	CO-5	R2:15.0
36	Bipropellant, monopropellant, cold gaspropellant, cryogenicpropellant, storablepropellants, gelledpropellant;	CO-6	T2:7.1
37	Propellant Storage, different propellant tank arrangements, control.	CO-6	T2:7.1
38	Propellant feed system-pressure feed, turbo-pump feed; Thrust chambers, injectors	CO-6	T2:33.4 R3:19.4
39	Combustion chamber, nozzle, starting and ignition, variable thrust	CO-6	T1:15.0, 33.9 R3:19.4
40	Combustion of liquid propellants: Combustion process, combustion instability, Thrust vector	CO-6	T1:15.0, 33.9 R3:19.4
PROBLEM SOLVING/ CASE STUDIES			
1	Problems on aircraft engine performance parameters, specific thrust, specific fuel consumption	CO 1	T1-6.2, 6.3
2	Problems on aircraft engine performance, specific impulse, thermal efficiency, propulsive efficiency	CO 1	T1-2.13, 2.14 and 2.16
3	Problems on aircraft engine overall efficiency	CO 2	T1-3.9, 3.6
4	Problems on performance analysis of aircraft engine	CO 2	T1-2.13, 2.14 and 2.16
5	Problems on design varibles on subsonic inlets	CO 3	T1-2.2, 2.6
6	Problems on design varibles on supersonic inlets	CO 3	R1-2.3, T2-6.1, 6.3
7	Problems on performance analysis on engine nozzle	CO 3	R1-2.3, T2-6.1
8	Problems on velocity triangles of engine compressor blades	CO 4	T1-3.6, 3.8
9	Problems on velocity triangles of engine turbine blades	CO 4	T1-35
10	Problems on design variables of compressor and turbine	CO 4	T1-3.2, 3.3
11	Problems on solid propellant grain configuration	CO 5	R2:15.0
12	Problems on design of burning rate of solid propellant rocket	CO 5	T2:11.3
13	Problems on design of rocket nozzle	CO 6	T2:7.1

14	Problems on rocket engine thrust vector control	CO 6	T2:33.4 R3:19.4
15	Problems on liquid propellant rocket combustion instability	CO 6	T1:15.0, 33.9 R3:19.4
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Engine performance parameters, specific thrust, specific fuel consumption and specific impulse, thermal efficiency, propulsive efficiency	CO-1	T1-3.2, 3.3
2	Subsonic and supersonic inlets: Function, design variables, operating conditions, inlet performance, performance parameters	CO-3	T1-3.2, 3.3
3	Geometry, definition of flow angles, stage parameters, cascade aerodynamics, aerodynamic forces on compressor and turbine blades,	CO-4	T1-3.2, 3.3
4	Total and specific impulse, effective exhaust velocity, rocket efficiencies, characteristic velocity, thrust coefficient	CO-5	T1-3.2, 3.3
5	Combustion chamber, nozzle, starting and ignition, variable thrust, Combustion of liquid propellants: Combustion process, combustion instability, Thrust vector	CO-6	T1-3.2, 3.3
DISCUSSION OF QUESTION BANK			
1	Classification, operational envelopes; Description and function of gas generator, turbojet, turbofan	CO 1,2	R1-2.6, 2.10
2	Combustors and Afterburners: Ignition and engine starting, adiabatic flame temperature, pressure losses, performance maps, fuel types and properties.	CO 3	R1-2.3, T2-6.1, 6.3
3	Different grain cross sections, propellant burning rate, combustion of solid propellants, physical and chemical processes	CO 4	R1-2.6, 2.10
4	Bipropellant, mono propellant, cold gas propellant, cryogenic propellant, storable propellants, gelled propellant	CO 5	R2, 3.0, T2:12.2
5	Electric propulsive rocket operation and its characteristics	CO 6	T1:15.0, 33.9 R3:19.4

Signature of Course Coordinator **HOD,**
Mr. Gooty Rohan, Assistant Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

<table>
<tr><td>Course Title</td><td colspan="5">EXPERIMENTAL AERODYNAMICS</td></tr>
<tr><td>Course Code</td><td colspan="5">AAE509</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td>VI</td><td colspan="4">AE</td></tr>
<tr><td>Course Type</td><td>Elective</td><td colspan="4"></td></tr>
<tr><td>Regulation</td><td>IARE - R16</td><td colspan="4"></td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>3</td><td>-</td><td>3</td><td>-</td><td>-</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Dr Prasanta Kumar Mohanta Professor</td></tr>
</table>

I COURSE OVERVIEW:

Experimental aerodynamics 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.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AAEB10	IV	Aerodynamics
UG	AAEB15	V	High Speed Aerodynamics

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
EXPERIMENTAL AERODYNAMICS	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
40 %	Understand
50 %	Apply
10 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

Quiz - Online Examination

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

Alternative Assessment Tool (AAT)

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

Concept Videos	Tech-talk	Open Ended Experiment
40%	40%	20 %

VI COURSE OBJECTIVES:

The students will try to learn:

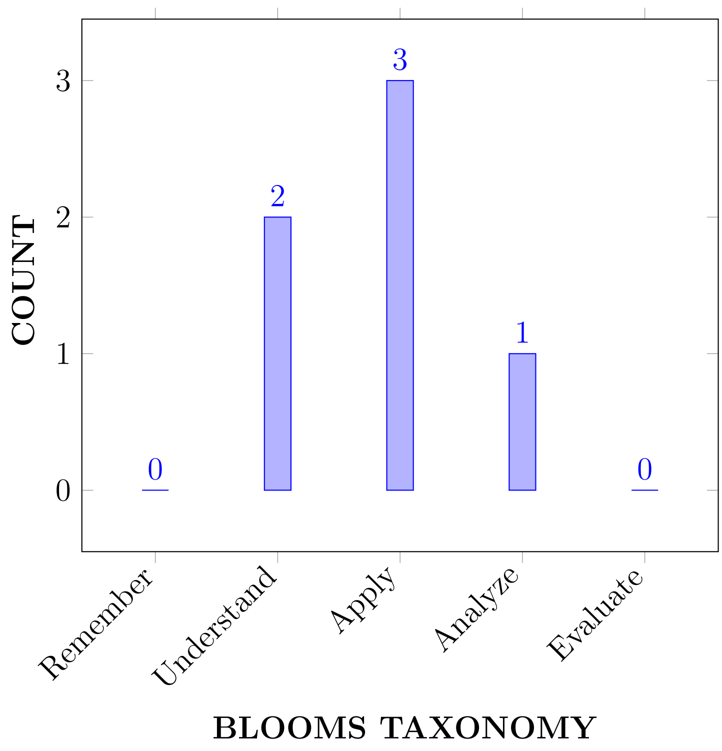
I	The constructions of low speed tunnel, high speed tunnels, transonic, supersonic and hypersonic tunnels and geometric similarity, kinematic similarity and dynamic similarity experiment techniques used for analysis aerodynamic problems.
II	The description, design constraints and loss coefficients, and 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 over a prototype models.	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 HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	3	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

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

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

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	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**)	6
	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**)	5
	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**)	5
	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**)	5
	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**)	5
	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.	5

	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**)	5
	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

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

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

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

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

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

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

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO1,PO2, PSO1	SEE Exams	PO1,PO2, PSO1	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	Concept Video	PO1, PO2, PSO1	Open Ended Experiments	-
Assignments	PO1, PO2, PSO1				

XVI ASSESSMENT METHODOLOGY INDIRECT:

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

XVII SYLLABUS:

MODULE I	**FUNDAMENTALS OF EXPERIMENTS IN AERODYNAMICS**
	Forms of aerodynamic experiments, observations, measurement objectives. History: Wright Brothers wind tunnel, model testing, wind tunnel principles, scaling laws, scale parameters, geometric similarity, kinematic similarity& dynamic similarity. Wind tunnels: low speed tunnel, high speed tunnels, transonic, supersonic and hypersonic tunnels, shock tubes. Special tunnels: low turbulence tunnels, high Reynolds number tunnels, environmental tunnels, automobile tunnels, distinctive features, application.
MODULE II	**WIND TUNNEL EXPERIMENTATION CONSIDERATIONS**
	Low speed wind tunnels, principal components. Function, description, design requirements, constraints and loss coefficients. Wind tunnel performance flow quality, power losses, wind tunnel corrections, sources of inaccuracies: buoyancy, solid blockage, wake blockage, streamline curvature causes, estimation and correction.
MODULE III	**WIND TUNNEL BALANCE**
	Load measurement: low speed wind tunnel balances, mechanical & Strain gauge types, null displacement methods & strain method, sensitivity, weigh beams, steel yard type and current balance type, balance linkages, levers and pivots. Model support three point wire support, three point strut support, platform balance, yoke balance, strain gauge, 3-component strain gauge balance, description, application.
MODULE IV	**PRESSURE, VELOCITY & TEMPERATURE MEASUREMETNS**
	Pressure: static pressure, surface pressure orifice, static probes, pitot probe for total pressure, static pressure and flow angularity, pressure sensitive paints, steady and unsteady pressure measurement and various types of pressure probes and transducers, errors in pressure measurement. Temperature: measurement of temperature using thermo couples, resistance thermometers, temperature sensitive paints and liquid crystals. Velocity: measurement of airspeed, Mach number from pressure measurements, flow direction, boundary layer profile using pitot static probe, 5 hole probe yaw meter, total head rake, hot wire anemometry, laser doppler anemometry, particle image velocimetry, working principle description of equipment, settings, calibration, measurement, data processing, applications.
MODULE V	**FLOW VISUALIZATION TECHNIQUES**
	Flow visualization: necessity, streamlines, streak lines, path lines, time lines, tufts, china clay, oil film, smoke, hydrogen bubble. Optical methods: density and refractive index, schlieren system, convex lenses, concave mirrors, shadow graph, interferometry, working principle, description, setting up, operation, observation, recording, interpretation of imagery, relative merits and applications.

TEXTBOOKS

1. 1. Jewel B Barlow, William H Rae Jr. & Alan Pope, "Low Speed Wind Tunnel Testing", John Wiley& Sons Inc, Re-Print, 1999.
2. Alan Pope, Kennith L Goin, "High Speed Wind Tunnel Testing", John Wiley & Sons, 1965.

REFERENCE BOOKS:

1. 1. Gorlin S M &Slezinger II, Wind tunnels & Their Instrumentations, NASA publications, Translated version, 1966.
2. 2. Jorge C Lerner &UlfilasBoldes, Wind Tunnels and Experimental Fluid Dynamics research, InTech, 1st Edition, 2011.
3. 3. Liepmann H W and Roshko A, Elements of Gas Dynamics, John Wiley & Sons, 4th Edition, 2003.

XVIII COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course description CO and PO mapping	-	-
CONTENT DELIVERY (THEORY)			
1	Introduction and need of experimental test	CO 1	T1: 1.1
2	Forms of aerodynamic experiments, observations, measurement objectives	CO 1	T1: 1.1, 1.2
3	History: Wright Brothers wind tunnel, model testing, Wind tunnel principles,	CO 1	T2: 1.1
4	Scaling laws, scale parameters, Geometric similarity, kinematic similarity& dynamic similarity.	CO 1	T1: 1.3
5	Wind tunnels: low speed tunnel, High speed tunnels	CO 1	T1: 2.3, T2: 1.2
6	Transonic, supersonic and Hyper-sonic tunnels	CO 1	T2: 1.3
7	Shock tubes, Special Wind tunnels	CO 1	T1: 2.5, 2.6
8	Wind tunnels for industrial and various applications apart from aerospace requirements	CO 1	T1: 2.7-2.10
9	Low speed wind tunnels, principal components	CO 2	T1: 3.2
10	Function, description, design requirements	CO 3	T1: 3.2
11	constraints and loss coefficients	CO 2	T1: 3.4
12	Wind tunnel performance flow quality, power losses	CO 2	T1: 3.11
13	Wind tunnel corrections, Sources of inaccuracies: buoyancy	CO 4	T2: 9
14	Solid blockage, wake blockage	CO 3	T1: 9
15	Streamline curvature causes, estimation and correction.	CO 3	T1: 9
16	Load measurement: low speed wind tunnel balances, mechanical	CO 4	T1: 7
17	Strain gauge types, null displacement methods & strain method	CO 4	T1: 7.3
18	Sensitivity, weigh beams, steel yard type and current balance type	CO 4	T1:7.4
19	Model support three point wire support, three point strut support	CO 4	T1: 7.4
20	Platform balance, yoke balance	CO 4	T1: 7.4
21	Strain gauge, 3-component strain gauge balance	CO 4	T1: 7.4
22	3-component strain gauge balance, Description, Application	CO 4	T1: 7.4

23	Pressure: static pressure, surface pressure orifice, static probes	CO 5	T1: 4.1
24	Pitot probe for total pressure, static pressure and flow angularity	CO 5	T1:4.3
25	Pressure sensitive paints, steady and unsteady pressure measurement	CO 5	T1: 4.1
26	Various types of pressure probes and transducers, errors in pressure measurement	CO 5	T1: 4.1
27	Temperature: measurement of temperature using thermo couples, resistance thermometers	CO 5	T1: 4.2
28	Temperature sensitive paints and liquid crystals. Velocity: measurement of airspeed	CO5	T1: 4.2
29	Mach number from pressure measurements, flow direction, boundary layer profile using pitot static probe	CO 5	T2: 6.2
30	5 hole probe yaw meter, total head rake, Hot wire anemometry	CO5	T2: 6.14
31	Laser Doppler anemometry and working principle	CO5	T1: 4.3
32	Data processing tools and applications	CO 5	T1: 4.1
33	Flow visualization: necessity, streamlines, streak lines, path lines, time lines	CO 6	T1: 5.1
34	tufts, china clay, oil film	CO 6	T1:5.3
35	smoke, hydrogen bubble	CO 6	T1: 5.4
36	Optical methods: density and refractive index, schlieren system	CO 6	T2: 6.17
37	Convex lenses, concave mirrors, shadow graph, interferometry	CO 6	T2: 6.16
38	Interferometry, working principle, description, setting up, operation	CO 6	T2: 6.18
39	observation, recording, interpretation of imagery	CO 6	T2: 6.18
40	relative merits and applications.	CO 6	T2: 6.19
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Different Types of Low speed wind tunnel	CO 1	T1: 2.3
2	Different types of high speed wind tunnel	CO 1	T2: 1.2
3	Kinematic, dynamic, geometric similarities	CO 1	T1: 1.3
4	Test section blockage ratio	CO 2	T1:1.9
5	Energy Gyration	CO 2	T1: 7.4
6	Loads and forces measured in platform-type balance	CO 4	T1: 7.4
7	Loads are forces measured in Yoke-type balance?	CO 4	T1: 7.4
8	Balance calibration	CO 4	T1:7.4
9	Pitot static tube, u tube manometer	CO5	T1 : 4.1
10	particle Image velocimetry	CO 5	T1: 4.3
11	Air speed measurements	CO 5	T1 : 4.3

12	Flow visualization techniques used in wind tunnel?	CO 6	T1: 5.1
13	Components of Shadow graph system?	CO 6	T2: 6.16
14	Components of schlieren system?	CO 6	T2: 6.17
15	Merits and demerits of flow visualization techniques	CO6	T2: 6.19
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Module: I- Fundamentals of Experiments in Aerodynamics	CO 1	T1, T2, R1, R2
2	Module: II- Wind Tunnel Experimentation Considerations	CO 2, CO 3	T1, T2, R1, R2
3	Module: III- Wind Tunnel Balance	CO 4	T1, T2, R1, R2
4	Module: IV- Pressure, Velocity and Temperature Measurements	CO 5	T1, T2, R1, R2
5	Module: V- Flow Visualization Techniques	CO 6	T1, T2, R1, R2
DISCUSSION OF QUESTION BANK			
1	Module: I- Fundamentals of Experiments in Aerodynamics	CO 1	T1, T2, R1, R2
2	Module: II- Wind Tunnel Experimentation Considerations	CO 2, CO 3	T1, T2, R1, R2
3	Module: III- Wind Tunnel Balance	CO 4	T1, T2, R1, R2
4	Module: IV- Pressure, Velocity and Temperature Measurements	CO 5	T1, T2, R1, R2
5	Module: V- Flow Visualization Techniques	CO 6	T1, T2, R1, R2

Signature of Course Coordinator **HOD,AE**
Dr Prasanta Kumar Mohanta Professor

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**AIRCRAFT STABILITY AND CONTROL**				
Course Code	AAE014				
Program	B.Tech				
Semester	V				
Course Type	CORE				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. Yagya Dutta Dwivedi,Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB0113	IV	Aircraft Performance

II COURSE OVERVIEW:

Aircraft Stability and Control is the science that investigates the stability and control of aircrafts and all other flying vehicles. From the advent of the first flight by the Wright Brothers, it was observed that flight without knowledge of stability and control was not viable. Since then, several different concepts for controlling aircraft flight have been devised including control surfaces, deformable surfaces, morphing of wings etc. This course introduces some of these concepts and describes their operation, as well as the degree of stability that these devices can provide. Modern aircraft control is ensured through automatic control systems known as autopilot. Their role is to increase safety, facilitate the pilot's task and improve flight qualities. The course will introduce modern aircraft stability and control and discuss some of its objectives and applications.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Aircraft Stability and Control	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

terms of marks distribution. The question paper pattern is as follows.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
15%	Understand
70%	Apply
15%	Analyze

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

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz /AAT	
Max.CIA Marks	25	5	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8th and 17th week of the semester respectively. The CIE exam is conducted for 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. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Internal Examination.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 20 multiple choice questions and are be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in the testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quizzes for every course.

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

VI COURSE OBJECTIVES:

The students will try to learn:

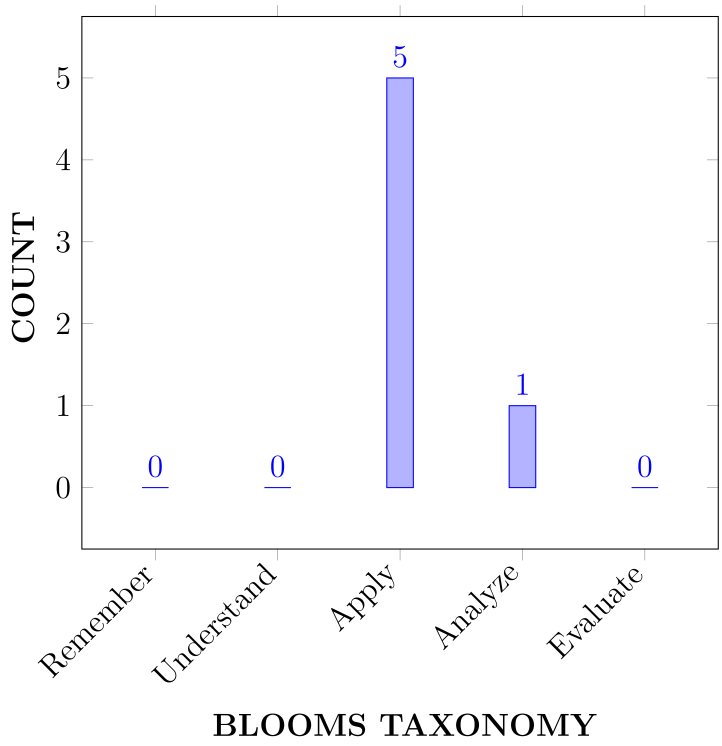
I	The fundamental knowledge on static stability of aircraft in multiple directional motions with their relationship for critical applications in flight vehicles.
II	The aircraft equations of motion to correlate qualitatively with potential applications in aircraft stability in different degrees of freedom (DOF).
III	The methods of optimizing the aircraft equations of motion and its derivatives for aircraft dynamic stability in various flight modes.
IV	The utilization of advances of flight dynamics and control in design and development of modern airplane control systems

VII COURSE OUTCOMES:

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

CO 1	**Identify** the concept of static stability in longitudinal, lateral and directional modes by using mathematical expression for different aircrafts stability conditions.	Apply
CO 2	**Solve** the design problems of the airframe components considering the aircraft static stability by using stability criteria equations and plots.	Apply
CO 3	**Apply** 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 behaviour 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.

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.	5	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.	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 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	2	Quiz

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	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	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	Understand the given **problem statement** and **formulate** the effect of horizontal tail on longitudinal static stability **using first principles of mathematics, natural sciences, and engineering sciences**	5
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
	PSO 2	Apply (knowledge) the concept of to assess aircraft behavior in different stages of aircraft flight **mathematics, science and engineering**	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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Apply (knowledge)the given **problem statement** and **formulate** the appropriate stability conditions for c.g location with respect to neutral point to reach substantiated conclusions with **provided information** and substantiate with the **interpretation** of variations in the results	4
CO 5	PO 1	Apply the basic flight laws of **science** for various phenomena of lateral and directional static stability and use **knowledge of mathematics, science and engineering fundamentals engineering fundamentals** of stability and control.	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 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 by the **interpretation of results.**	4
	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**	2

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

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

CO 4	3	4	-	-		-	-	-	-	-	-		-	-	-
CO 5	3	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	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	50	-	-	-	-	-	-	-	-	-	-	-	100	-
CO 4	100	40	-	-		-	-	-	-	-	-		-	-	-
CO 5	100	40	-	-	-	-	-	-	-	-	-	-	-	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	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 6	3	1	-	-	-	-	-	-	-	-	-	-	-	3	-
TOTAL	18	7	-	-	-	-	-	-	-	-	-	-	-	9	-
AVERAGE	3	1.4	-	-	-	-	-	-	-	-	-	-	-	3	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	PO 1,PO 2	SEE Exams	PO 1,PO 2	Assignments	PO 1, PO 2
Laboratory Practices	-	Student Viva	-	Certification	-
Tech talk	PO 1, PO 2	Concept Video	PO 1, PO 2	Open Ended Experiments	PO 1, PO 2
Seminars	-				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**INTRODUCTION AND LONGITUDINAL STABILITY - I**
	Aircraft axes system, definition: equilibrium, stability, controllability and maneuverability. Examples from simple mechanical systems for stability. Longitudinal static stability and dynamic stability for un accelerated flight. Criteria for longitudinal static stability and trim condition. Contribution of Principle components. Equations of equilibrium- stick fixed neutral point, elevator angle required to trim. Definition-static margin. Equations of motion in steady, symmetric pull-up maneuver, elevator effectiveness, elevator hinge moment, neutral point, maneuver point, static margin for stick fixed and stick free conditions, control force and control gradient. Trim tabs and types of trim tabs, aerodynamic and mass balancing of control surfaces, forward and aft most limits of CG.
MODULE II	**LATERAL-DIRECTIONAL STATIC STABILITY**
	Introduction to lateral-direction stability- aerodynamic forces and moments, aircraft side force due to side slip, aircraft rolling moment due to side slip and aircraft yawing moment due to side slip. Aircraft component contribution on directional static stability, Aircraft component contribution for lateral-directional stability, rudder requirements.
MODULE III	**AIRCRAFT EQUATION OF MOTION**
	Description of motion of flight vehicle - systems of reference frames - Earth, body, wind, stability axes - relative merits. Euler angles, angles of attack and sideslip– definitions- Earth to body axis transformation, stability axis to body axis transformation. Rotating axis system- expressions for linear and angular moment of rigid body, time derivatives-inertia tensor, components of linear and angular velocities, accelerations. Components of aerodynamic, gravity forces, moments applied on flight vehicle. Equations of motion- longitudinal and lateral-directional. Relation between angular velocity components and Euler angle rates. Determination of velocities of airplane in Earth axis system.
MODULE IV	**LINEARIZATION OF EQUATIONS OF MOTION AND AERODYNAMIC FORCES AND MOMENTS DERIVATIVES**
	Description of state of motion of vehicle, forces and moments as perturbations over prescribed reference flight condition. Equation of motion in perturbation variables. Assumption of small perturbations, first order approximations- linearization equations of motion. Linearized of force and moment equation, of motion Linearized longitudinal and lateral-directional equations of perturbed motion. Significance of aerodynamic derivatives. Derivatives of axial, normal force components and pitching moment with respect to the velocity, angle of attack, angle of attack rate, pitch rate, elevator angle.
MODULE V	**AIRCRAFT DYNAMIC STABILITY**

	Principle modes of motion characteristics, mode shapes and significance, time constant, undamped natural frequency and damping ratio- mode shapes- significance. One degree of freedom, two degree of freedom approximations- constant speed (short period), constant angle of attack (long period) approximations- solutions. Determination of longitudinal and lateral stability from coefficients of characteristic equation- stability and lateral stability from coefficients of characteristics equation- stability criteria, Aircraft spin- entry, balance of forces in steady spin

TEXTBOOKS

1. . Yechout, T.R. et al., "Introduction to Aircraft Flight Mechanics", AIAA education Series, 2003, ISBN 1-56347-577-4.
2. Nelson, R.C., "Flight Stability and Automatic Control", 2nd Edn., Tata McGraw Hill, 2007, ISBN 0-07-066110-3.
3. Etkin, B and Reid, L.D., "Dynamics of Flight", 3rd Edn., John Wiley, 1998, ISBN0-47103418-5.

REFERENCE BOOKS:

1. 1. Schmidt, L.V., "Introduction to Aircraft Flight Dynamics", AIAA Education Series, 1st Edition, 1998, ISBN A-56347-226-0.G.
2. 2. McCormick, B.W., "Aerodynamics, Aeronautics, and Flight Mechanics", Wiley India, 2nd Edition, 1995, ISBN 97.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112105171/1
2. https://textofvideo.nptel.iitm.ac.in/112105171/lec1.pdf
3. https://www.fkm.utm.my/ syahruls/3-teaching/2-fluid-II/fluid-II-enote/32-pump-2.pdf
4. https://www.scribd.com/doc/16605891/Fluid-Mechanics

COURSE WEB PAGE:

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1			
CONTENT DELIVERY (THEORY)			
2	Introduction Aircraft Stability.	CO 1, 2	T2: 1.1-1.5, T1: 4.1
3	Introduction to Stability and Control	CO 1	T2: 2.1-2.2, R1: 3.1
4	Stability and Trim	CO 1	T2: 2.1-2.2, R1: 3.1
5	Wing Contribution on Static Longitudinal Stability	CO 1	R4: 2.8
6	Basic concepts about airplane static stability	CO 1	T2: 2.3-2.4

7-8	Tail Contribution on Static Longitudinal Stability	CO 1	R4: 2.7.1
8	Neutral Point and Static Margin	CO 1	R4: 2.7.1
9	Neutral Point and Fuselage contribution on Longitudinal Static Stability	CO 1	T2: 3.4
10	Numerical Problems Stability and Tail Contribution	CO 1	T2: 3.4
11	Longitudinal Control	CO 1	T2: 3.3
12	Longitudinal Control and Revision	CO 1	T4: 7.1
13	Control: Elevator	CO 2	R4: 6.3.3
14	CL trim Vs δ_e Trim and Numerical	CO 2	R4: T6.3.2
15	Trim at airplane Cruise, climb and Landing	CO 2	R4: T6.3.2
16	Trim: Maneuver	CO 2	R4: T6.3.2
17	Maneuver Point- Stick Fixed	CO 2	T1 5.5
18	Elevator required at different maneuver with numerical	CO 2	R4: 7.1
19	Directional Stability and Control	CO 2	T2: 5.1
20	Lateral Stability and control	CO 2	T2: 5.2
21	Stick free stability	CO 3	R4: 4.2.1
22	Hinge moment and hinge derivative	CO 3	R4: 4.2.2
23	Aircraft Handling Qualities	CO 3	T1: 5.2
24	Reversible Control: Stick free and Trim Tabs	CO 3	T2: 6.3-6.4
25	Point mass Equations of motion,	CO 3	T2: 5.2
26	Forces and moments	CO 4	T2: 5.2
27	Aircraft Equations of motion	CO 4	T2: 5.2
28	6-DOF, Angular momentum component	CO 4	T2: 13.1-13.2
29	Vector in a Rotating Frame	CO 4	T2: 13.1-13.2.5
30	Euler's Angle	CO 4	T2: 13.2.6
30	Small perturbation theory	CO 4	T2: 13.2.7
31	Perturbed Equations of motion- Longitudinal case	CO 4	T4: 11.1-11.2
32	Perturbed force- Fz	CO 4	T4: 11.2-11.4
33	Longitudinal Dimensional Stability Derivatives	CO 5	T1:11.1, T4:14.1
34	Dynamic stability	CO 5	T1:11.1, T4:14.4
35	Longitudinal Modes	CO 5	T1:11.2-11.4, T4:14.3
36	Pure pitching Motion	CO 5	R4:15.3.1
37	Stability Augmentation system	CO 6	T1:11.1, T4:14.3-14.4
38	Lateral Directional Motion	CO 6	R4:15.4
39	Dynamic stability and its modes	CO 6	R4:15.3.1
40	Characteristics equation and stability criteria with Routh laws	CO 6	T4:14.3-14.4
PROBLEM SOLVING/ CASE STUDIES			
1	Numerical Problems Wing Contribution on Static Stability	CO 1	T2: 1.1-1.5, T1: 4.1
2	Numerical Problems Stability and Tail Contribution	CO 1	T2: 3.4

3	Elevator required at different maneuver with Numerical	CO 2	R4: 2.8
4	Numerical on Maneuvering point	CO 2	R4: T6.3.2
5	Numerical directional, lateral stability	CO 3	R4: T6.3.2
6	CL trim Vs δ_e Trim and Numerical	CO 3	R4: T6.3.2
7	Determination of Neutral point and maneuvering point	CO 4	R4:5.2
8	Revision of Longitudinal static stability,	CO 5	T2:5.2
9	Static stability Numerical- Problem framing	CO 5	T2: 5.2
10	Stick Fixed and Stick free static stability	CO 5	T2: 13.1-13.2.5
11	Problems of Dynamic Stability and revision	CO 5	T4: 11.2-11.4
12	Frequency related Problem and solution	CO 6	T2: 13.2.6
13	Elevator power numerical	CO 6	T4:14.3-14.4
14	Problems of tail/ wing combination	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	R4:5.1, T2: 6.3-6.4
4	Velocity derivative, AOA derivative, Mach tuck derivative, Perturbation theory,	CO 4	T1:7.5
5	Dynamic stability, Dynamic modes, natural frequency, Damping ratio, Longitudinal modes, Lateral and direction dynamic modes	CO 5	T1: 12.1
DISCUSSION OF QUESTION BANK			
1	Analysis of longitudinal static stability.	CO 1	T2: 1.1-1.5
2	Analysis of lateral and directional static stability.	CO 2	R4: T6.3.2
3	Derivation and mathematical formulations of Equations of motion for aircraft.	CO 3	R4:5.1
4	Use of perturbation theory for the simplification of the equations of motions and its applications.	CO 4	T4: 11.2-11.4
5	Effects of the dynamic stability of the airplane. Modes of dynamic stability and formulations.	CO 5	T1:11.2-11.4, T4:14.3

Signature of Course Coordinator **HOD,AE**
Dr. Yagya Dutta Dwivedi, Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**Computational Aerodynamics Laboratory**				
Course Code	AAE109				
Program	B.Tech				
Semester	VI	AE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Mr. A. Rathan Babu, Assistant Professor				

I COURSE OVERVIEW:

Computational Aerodynamics laboratory sessions focus on the creation of geometry, meshing (Discretization) and the physics applied to aerodynamics in order to visualize fluid flow and temperature distribution, and estimating the flow parameters around the aerodynamic body. Computational Aerodynamics laboratory also covers the usage of finite difference methods and necessary coding techniques. In this lab course, the students are trained on conducting simulations using the numerical methods analysis tool of CAD systems. The simulations include fluid, structural, thermal systems in the emerging technologies of interdisciplinary applications such as mechanical, aerospace, refrigeration systems.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB03	IV	Aerodynamics

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Computational Aerodynamics Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	The concepts of grid generation techniques for simple and complex domains to model fluid flow problems.
II	The aspects of numerical discretization techniques such as finite volume and finite difference methods.

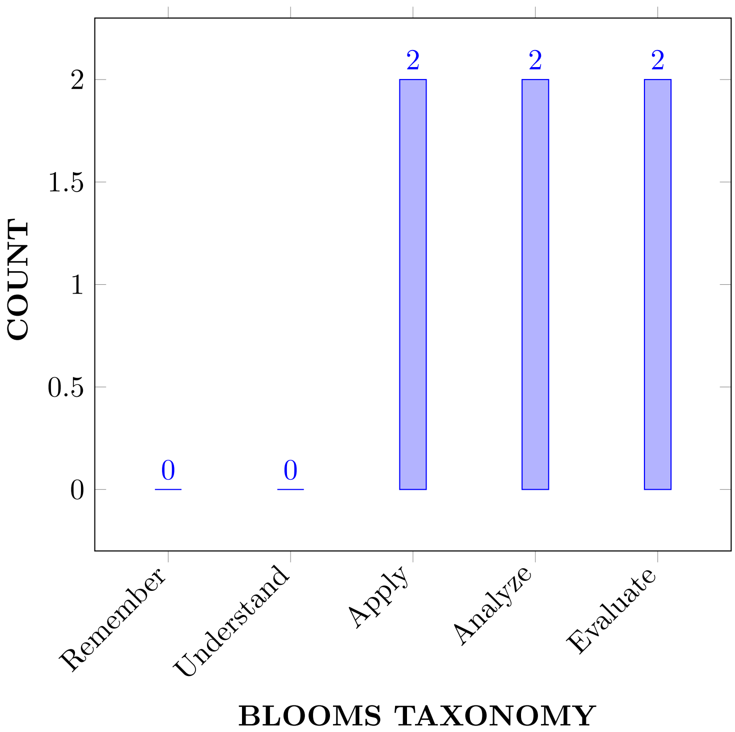
III	The mathematical modeling of different classes of partial differential equations to show their impact on computational fluid dynamics.
IV	The characteristics of different turbulence models and numerical schemes for estimating the criteria of stability, convergence, and error of fluid flow problem.

VII COURSE OUTCOMES:

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

CO 1	**Choose** the finite difference method at grid points of the domain for understanding discretization technique in solving fluid flow problem.	Apply
CO 2	**Classify** the nature of fluid flow problems for solving the governing equations using computational methods.	Analyze
CO 3	**Make use of** the computational methods and algorithms for obtaining solutions of fluid flow problems using ANSYS.	Apply
CO 4	**Simplify** the parameters of thermo-fluid systems using simulation methods for validating numerical and experimental results.	Analyze
CO 5	**Estimate** the aerodynamic forces on the slender and bluff bodies for calculating the lift and drag coefficients.	Evaluate
CO 6	**Assess** the numerical solution of fluid flow problems using discretization methods and convergence criteria for better results and minimize the errors.	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Lab Exercises/CIE/SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	Lab Exercises/CIE/SEE
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Lab Exercises/CIE/SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	Lab Exercises/CIE/SEE
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	3	Lab Exercises/CIE/SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Lab Exercises/CIE/SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	3	Lab Exercises/CIE/SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the basic conservation laws of science for various phenomena of fluid systems and use mathematical principles**mathematical principles** for deriving (complex) fluid flow engineering equations by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals**of fluid mechanics	3
	PO 2	Develop the computational programs for governing equations of fluid flow problems from the **temperature distribution** and velocity propagation are calculated from numerical methods using **mathematical principles** and **engineering fluid thermal sciences.**	2
	PO 3	**Identify**the available partial differential equations (analytical methods) for engineering fluid flow problems and apply a **computer software (CFD)** to **provide solutions** by **analyzing** analyzing the processes **in various applications**.	2
	PO 4	Outline the finite element methods adopted in **computational techniques**for **simulation**of fluid thermal systems for **innovative career**path in industry for **modern tool** usage.	2
	PO 5	Understand the (given **problem statement**) calibration procedure for (provided **information and data**) in reaching substantiated conclusions by the interpretation of results	3
	PO 9	Understand the (given **problem statement**) effects of viscosity, and capillary rise for the bodies immersed in fluids. (from the provided **information**) in solving analysis problems.	3
	PO 10	Recognize (knowledge) the importance and application (apply) of dimensions, units and dimensional homogeneity in solving (complex) engineering problems with specific emphasis to fluid mechanics by applying the **principles of Mathematics, Science and Engineering**	2
	PO 12	Understand the given **problem statement and formulate** the dimensional analysis and similarity parameters for predicting physical parameters that govern fluid systems in designing prototypes devices	3
	PSO 3	Apply (**knowledge**) properties, various types and patterns of fluid flow configurations (apply) for solving design problems by applying the **principles of Mathematics, Science and Engineering**	2

CO 2	PO 1	Develop the computational programs for governing equations of fluid flow problems from the **mathematical principles** and **engineering fluid thermal sciences.**	3
	PO 2	Identify the principles associated with heat transfer to **formulate** and calculate the flow field variables **using principles of mathematics, Design and engineering sciences.**	2
	PO 3	**Develop the Product, identify the proper solution** method for thermal equipment's used **in various applications** in the design and **evaluation of outcomes.**	2
	PO 4	**Identify the differential equations** (analytical methods) for engineering fluid flow problems and apply computer software (CFD) to provide solutions by analyzing the processes.	2
	PO 5	**Choose the necessary discretization methods to analyse** the stability of fluid system in the aspect of design the problems experimentally and numerically to recognize the significance of them in solving various engineering problems and creating solutions for thermal systems.	3
	PO 9	Understand fluid flow processes and the corresponding the context of **engineering knowledge related to different methods** of CFD and analyse the basic parameters influencing the flow by incorporating commercial CFD codes.	3
	PO 10	Understand the customer requirement, identify the proper finite differenece method for **complex thermal systems used in various applications**.	2
	PO 12	Apply appropriate finite difference technique to solve the complex thermal problems.	3
	PSO 3	Develop practical experience in building the real time products, using **industry standard and collaboration technique** in the field of Heat Exchangers.	2
CO 3	PO 1	Understand the given **problem statement and formulate** (complex) engineering problems by modeling ,meshing and applying corresponding boundary **information and data** in reaching substantiated conclusions by the**interpretation of results.**	3
	PO 2	**Identify**the available partial differential equations (analytical methods) for engineering fluid flow problems and apply a **computer software (CFD)** to **provide solutions** by **analyzing** analyzing the processes **in various applications**.	2
	PO 3	**Understanding** the basic processes to **conduct investigations of complex problems**in the **design, analysis to provide numerical solution** in order to minimize the T.E error.	2

	PO 4	Identify (Knowledge) the characteristics of various fluid flow processes, understand the corresponding the context of **engineering knowledge related to different methods** of CFD and analyse the basic parameters influencing the flow by incorporating commercial CFD codes.	2
	PO 5	Apply the available partial differential equations (analytical methods) for engineering fluid flow problems and apply computer software (CFD) to provide solutions by analyzing the processes.	3
	PO 9	Choose the necessary discretization methods to analyse the stability of fluid system in the aspect of design the problems experimentally and numerically to recognize the significance of them in solving various engineering problems and creating solutions for thermal systems.	3
	PO 10	**Apply the skills** of CFD methods in advanced industry trends based on engineering concepts.	1
	PO 12	Apply appropriate finite difference technique to solve the complex fluid problems.	3
	PSO 3	Develop practical experience in building the real time products, using **industry standard and collaboration technique** in the field of Heat Exchangers.	2
CO 4	PO 1	Select appropriate finite difference methods for numerical formulations from the fundamentals of mathematics and engineering **fluid thermal sciences.**	3
	PO 2	**Identify** and Understand the given fluid flow problem and **formulate**the appropriate CFD technique by using **first principles of mathematics** (Partial differential equations) to get analytical **solutions** in order to**validate results.**	2
	PO 3	Identify the various properties of condensation to heat engines techniques using**Design, analytical and mathematical process for problem analysis**	2
	PO 4	**Identify and Understand** the given fluid flow problem and formulate the appropriate CFD technique by using first principles of mathematics (Partial differential equations) to get analytical solutions in order to validate results.	3
	PO 5	**Formulate the problem statement and identify** the suitable finite difference method to obtain substantiated conclusions by the interpretation of results.	3
	PO 9	**Understand the customer requirement, identify** the proper finite volume method for complex thermal systems used in various applications.	3
	PO 10	Identify the available partial differential equations (analytical methods) for **engineering fluid flow problems and apply** computer software (CFD) to provide solutions by analyzing the processes.	2
	PO 12	**Build up (Apply) the skills** in the actual implementation of grid methods in industry trends based on advanced engineering concepts.	3

	PSO 3	Develop practical experience in building the real time products, using **industry standard and collaboration technique** in the field of Heat Exchangers.	3
CO 5	PO 1	**Analyse** the different discretization methods for solving thermal problems by using **engineering fundamentals in fluid sciences using mathematical equations** (partial differential equations) to minimise the errors.	3
	PO 2	Develop expression for aerodynamic coefficient and Identify the appropriate type of heat exchangers for **complex, problem analysis using engineering sciences.**	2
	PO 3	**Understand the customer (Product) requirement, identify the proper solution** method for thermal equipment's used **in various applications** in the design and **evaluation of outcomes.**	3
	PO 4	**Identify the available partial differential equations** (analytical methods) for engineering fluid flow problems and apply computer software (CFD) to provide solutions by analyzing the processes.	2
	PO 5	**Select the necessary discretization methods to analyse** the stability of fluid system in the aspect of design the problems experimentally and numerically to recognize the significance of them in solving various engineering problems and creating solutions for thermal systems.	3
	PO 9	Understand the characteristics of various fluid flow processes, understand the corresponding the context of **engineering knowledge related to different methods** of CFD and analyse the basic parameters influencing the flow by incorporating commercial CFD codes.	3
	PO 10	Understand the customer requirement, identify the proper finite volume method for **complex thermal systems used in various applications**.	3
	PO 12	Apply appropriate finite volume technique to solve the complex fluid thermal problems.	3
	PSO 3	Outline the finite volume methods adopted in **computational techniques for simulation** of fluid thermal systems for **innovative career** path in industry for**modern tool** usage.	3
CO 6	PO 1	Analyze the different discretization methods for solving thermal problems by using **engineering fundamentals in fluid sciences**using **mathematical equations** (partial differential equations) to minimize the errors.	3
	PO 2	**Identify, define** the necessary discretization methods to analyze the stability of fluid system in the aspect of **design** the problems experimentally and numerically to recognize the significance of them in **solving various engineering problems and creating solutions for thermal systems.**	2

	PO 3	**Knowledge and understanding** the basic processes to **conduct investigations of complex problems**in the **design, analysis to provide numerical solution** in order to minimize the error.	2
	PO 4	Recognize (Knowledge) the characteristics of various fluid flow processes, understand the corresponding the context of **engineering knowledge related to different methods** of CFD and analyse the basic parameters influencing the flow by incorporating commercial CFD codes.	3
	PO 5	Identify the available partial differential equations (analytical methods) for engineering fluid flow problems and apply computer software (CFD) to provide solutions by analyzing the processes.	3
	PO 9	Select the necessary discretization methods to analyse the stability of fluid system in the aspect of design the problems experimentally and numerically to recognize the significance of them in solving various engineering problems and creating solutions for thermal systems.	3
	PO 10	**Apply the skills in the actual implementation** of CFD methods in advanced industry trends based on engineering concepts.	2
	PO 12	Apply appropriate finite volume technique to solve the complex thermal problems.	3
	PSO 3	Outline the finite volume methods adopted in **computational techniques for simulation** of fluid thermal systems for **innovative career** path in industry for**modern tool** usage.	3

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

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

XIII ASSESSMENT METHODOLOGY DIRECT:

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

XIV ASSESSMENT METHODOLOGY INDIRECT:

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

XV SYLLABUS:

WEEK I	**INTRODUCTION**
	Introduction to computational aerodynamics, the major theories, approaches and methodologies used in computational aerodynamics. Applications of computational aerodynamics for classical aerodynamic's problems.
WEEK II	**INTRODUCTION TO ICEM CFD**
	Introduction to ICEM CFD, geometry creation, suitable meshing types and boundary conditions.
WEEK III	**INTRODUCTION TO FLUENT**
	Introduction to fluent, boundary conditions, solver conditions and post processing results.
WEEK IV	**FLOW OVER A FLAT PLATE**
	Flow over a flat plate at low Reynolds numbers, observe the boundary layer phenomena, no slip condition and velocity profile inside the boundary layer.
WEEK V	**FLOW THROUGH PIPE**
	Flow through pipe at different Reynolds numbers; observe the velocity changes for laminar and turbulent flows.
WEEK VI	**FLOW OVER A CIRCULAR CYLINDER**
	Flow over a circular cylinder at different Reynolds numbers, observe the properties at separation region and wake region.
WEEK VII	**FLOW OVER A CAMBERED AEROFOIL**
	Flow over a cambered aerofoil at different Reynolds number, observe flow properties and compare the computation results with experimental results (consider the model from aerodynamics laboratory).
WEEK VIII	**FLOW OVER A SYMMETRIC AEROFOIL**
	Flow over a symmetric aerofoil at different Reynolds number, observe flow properties and compare the computation results with experimental results (consider the model from aerodynamics laboratory).
WEEK IX	**FLOW OVER WEDGE**
	Flow over wedge body at supersonic Mach number; observe the shock wave phenomena and change of properties across the shock wave.
WEEK X	**FLOW OVER A CONE**
	Flow over a cone at supersonic Mach number; observe the shock waves and 3D relieving effect.
WEEK XI	**CODE DEVELOPMENT**
	Solution for the following equations using finite difference method I. One dimensional wave equation using explicit method of lax. II. One dimensional heat conduction equation using explicit method.
WEEK XII	**CODE DEVELOPMENT**

	Generation of the following grids I. Algebraic grids. II. Elliptic grids.

Reference Books:

1. Anderson, J.D., Jr., Computational Fluid Dynamics The Basics with Applications, McGraw-Hill Inc, 1st Edition 1998.

2. Hoffmann, K. A. and Chiang, S. T., —Computational Fluid Dynamics for Engineers, 4th Edition, Engineering Education Systems (2000).

3. Hirsch, C., —Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics, Vol. I, 2nd Edition., Butterworth-Heinemann (2007).

4. JAF. Thompson, Bharat K. Soni, Nigel P. Weatherill —Grid generation, 1st Edition 2000.

XVI COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Introduction.	CO 1	R1: 2.3
2	Introduction to ICEM CFD.	CO 3,CO 4,CO 6	R2: 2.6
3	Introduction to fluent.	CO 2, CO 3	R1: 2.6
4	Flow over a flat plate.	CO 3,CO 4,CO 6	R2: 2.7
5	Flow through pipe.	CO 3, CO 4	R3: 2.22
6	Flow over a circular cylinder.	CO 3, CO 4	R2: 2.25
7	Flow over a cambered aerofoil.	CO 4	R3: 2.55
8	Flow over a symmetric aerofoil.	CO 3, CO 4	R2: 2.3
9	Flow over wedge.	CO 4,CO 5	R1: 2.6
10	Flow over a cone.	CO 3,CO 4, CO 6	R2: 2.8
11	Code development.	CO 3,CO 6	R1:2.18
12	Code development.	CO 3,CO 6	R4:2.22

XVII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Aerodynamic analysis on wing.
2	Flow Through Diffuser.
3	Subsonic flow in a convergent divergent nozzle.
4	Analysis of heat pipe using volume of fluid method.
5	Flow through supersonic intake.

Signature of Course Coordinator **HOD,AE**
Mr.A. Rathan Babu, Assistant Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**COMPUTATIONAL STRUCTURAL ANALYSIS LABORATORY**				
Course Code	AAEB23				
Program	B.Tech				
Semester	VI	AE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Mr. Gooty Rohan, Assistant Professor				

I COURSE OVERVIEW:

Computational Structural Analysis Laboratory sessions focus on the creation of geometry, meshing (Discretization) and the physics behind the stress strain variation on a continuum. It will also cover the different solvers available in a FEA package and their applications based on the problem type. This course offers a wide range of applications in aircraft structural analysis such as deflection of truss, frames, beams, stress and strain distributions in a plate as well as a solid continuum. Apart from these, it will also address the nonlinear stress problems alongside vibration and flutter analysis.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB04	III	Mechanics of Solids
B.Tech	AAEB07	IV	Aerospace Structures
B.Tech	AAEB19	VI	Finite Element Analysis

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
CSA LAB	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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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
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20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

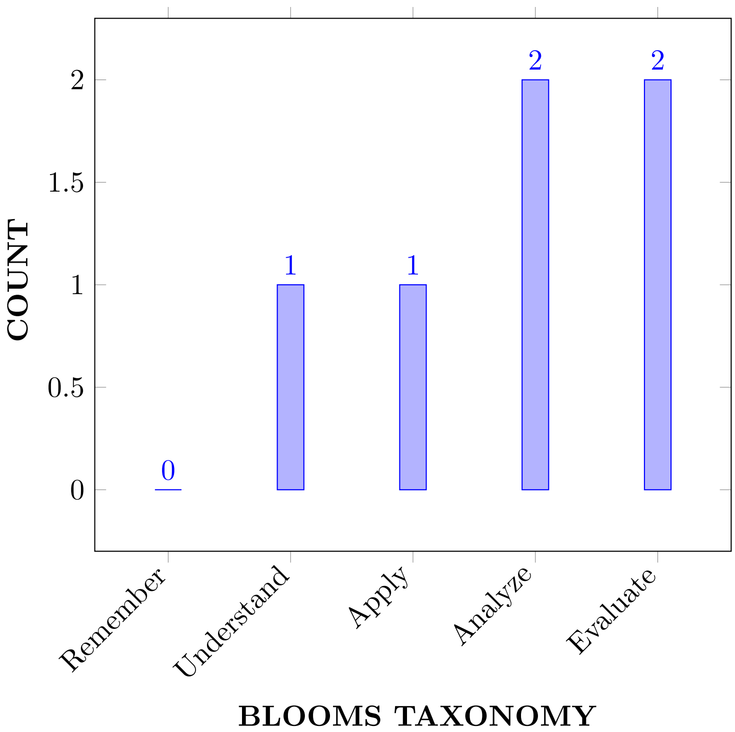
I	Make the student familiar with latest computational techniques and software used for structural analysis.
II	. Enable the student to get a feeling of how real-life structures behavior for static and dynamics loads.
III	. Become familiar with professional and contemporary issues in the design and fabrication.

VII COURSE OUTCOMES:

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

CO 1	**Explain** the computational methods and Softwares that are used in aerospace fields to simulate the complex problems through ANSYS.	Understand
CO 2	**Solve** the parameters like deflections, stress, strain and bending moment by using ANSYS for the linear and non-linear problems that occur in aircraft structural components (beams, bars etc.).	Apply
CO 3	**Calculate** the numerical solution of static structural problems using discretization methods and convergence criteria to minimize the errors.	Analyze
CO 4	**Select** the appropriate heat transfer mechanism using ANSYS thermal workbench for efficient cooling of on board avionics system.	Analyze
CO 5	**Predict** the suitable appropriate results using governing equations for vibrational problems that occur in aircraft structural components (beams, spring-mass system)	Evaluate
CO 6	**Determine** the nature of stress-strain distribution by using appropriate governing equations for an aircraft structural components such as wings, fuselage and landing gear.	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

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

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the basic conservation laws of science for various phenomena of fluid systems and use **mathematical principles** for deriving (complex) fluid flow engineering equations by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals** of fluid mechanics	3
	PO 2	Identify the physical problems with different surfaces and geometries(2D and 3D) for which the temperature distribution and velocity propagation are calculated from numerical methods using principles of **engineering mathematics and sciences.**	2
	PO 3	**Design/development a appropriate solutions** for complex engineering problems using the numerical methods (ANSYS)	3
	PO 4	Make a use of **research methodologies** to investigate the experimental, analytical data with numerical simulational results with ANSYS workbench	1
	PO 5	Identify the suitable **modern software** in order create, select and the apply for complex engineering problems to obtain results.	3
	PO 9	Understand the complex problems either by **individual or team work** to obtain the appropriate results.	3
	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments.	2
	PO 12	Apply the skills learnt in the lab to solve **real life problems** using ANSYS Workbench	3
	PSO 3	Outline the finite element methods adopted in **computational techniques** for **simulation** of fluid thermal systems for **innovative career** path in industry for **modern tool** usage.	3

CO 2	PO 1	Develop the computational programs for governing equations of structural analysis problems from the **mathematical principles** and **engineering fluid thermal sciences**.	3
	PO 2	Identify the principles associated with Static structural problems to **formulate** and calculate the deflection variables **using principles of mathematics, Design and engineering sciences**.	2
	PO 3	**Design/development a appropriate solutions** for complex static structural problems using the ANSYS workbench	3
	PO 4	Make a use of **research methodologies** to investigate the structural problems of the experimental, analytical data with numerical simulational results	3
	PO 5	Identify the suitable **modern software** in order create, select and the apply for linear and non-linear problems to obtain the results.	3
	PO 9	Understand the linear and non-linear structural problems either by **individual or team work** to obtain the approximate results.	3
	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments.	2
	PO 12	Apply the skills learnt in the ANSYS lab to identify the solutions for **real life problems** using suitable Workbench	3
	PSO 3	Outline the finite element methods adopted in **computational techniques** for **simulation** of structural systems for **innovative career** path in industry for **modern tool** usage.	3
CO 3	PO 1	Develop the computational programs for governing equations of structural analysis problems from the **mathematical principles** and **engineering fluid thermal sciences**.	3
	PO 2	Understand the given **problem statement and formulate** complex engineering problems by modeling ,meshing and applying corresponding boundary **information and data** in reaching substantiated conclusions by the **interpretation of results**.	2
	PO 3	**Design/development a appropriate solutions** for complex static structural problems using the ANSYS workbench	2
	PO 4	Make a use of **research methodologies** to investigate the static structural problems of the experimental, analytical data with numerical simulational results	3
	PO 5	Using the suitable **modern software (ANSYS)** in order to identify the solutions for static structural problems using appropriate mesh methods.	3

	PO 9	Understand the approximate results either by **individual or team work** for complex engineering problems through ANSYS.	3
	PO 10	Utilize the **communication skills to write lab related documents** for an effective communication with diverse engineering segments.	2
	PO 12	Apply the skills learnt in the ANSYS lab to identify the solutions for **real life problems** using suitable Workbench	3
	PSO 3	Outline the finite element methods adopted in **computational techniques** for simulation of static-structural systems to **innovative career** path in industry for **modern tool** usage.	2
CO 4	PO 1	Develop the computational programs for governing equations of structural analysis problems from the **mathematical principles** and **engineering fluid thermal sciences**.	3
	PO 2	**Identify** and Understand the given heat transfer problem and **formulate** the appropriate heat flow technique by using **first principles of mathematics** (Partial differential equations).	2
	PO 3	Identify the various techniques that are used to **Design/ develope a numerical solution** for an complex heat transfer problems with ANSYS.	3
	PO 4	Make a use of **research methods** to investigate the complex heat transfer problems to validate the numerical results with experimental data.	3
	PO 5	Using techniques that are in modern tools (ANSYS) to **create, select and apply** the solutions for various heat transfer problems	3
	PO 9	Understand the complex heat transfer problems either by **individual or team work** to identify the solutions through ANSYS.	3
	PO 10	Utilize the **communication skills to write lab related documents** for an effective communication with diverse engineering segments.	2
	PO 12	Apply the skills learnt in the ANSYS lab to identify the solutions for **real life problems** using suitable Workbench	2
	PSO 3	Outline the numerical methods adopted in **computational techniques** for simulation of heat flow systems to **innovative career** path in industry for **modern tool** usage.	3
CO 5	PO 1	Develop the computational programs for governing equations of vibrational analysis problems from the **mathematical principles** and **engineering sciences**.	3
	PO 2	**Identify and formulate** an expression for complex vibrational problems using governing equations with ANSYS.	2

	PO 3	**Design and develop** a solution for vibrational problems that meet the specified needs with appropriate consideration.	2
	PO 4	Make a use of engineering knowledge to **conduct an investigations of complex** vibrational problems using ANSYS.	3
	PO 5	Utilize the **Modern tools (ANSYS)** to create, select and apply the techniques for identifying the solution for complex problems.	3
	PO 9	Resolve the vibrational problems using appropriate techniques and identify the effective solutions either by **individually or team work**.	3
	PO 10	By using the **communication and report writing skills** to develop the effective lab document.	2
	PO 12	Apply the skills learnt in the ANSYS lab to identify the solutions for **real life problems** using suitable Workbench	3
	PSO 3	Make a use of **multi physics and computational methods** for bulding the career paths towards employability and higher studies.	2
CO 6	PO 1	Analyze the different discretization methods for identifying the stress-straindistribution by using **mathematics, science andengineering fundamentals** to minimize the errors.	3
	PO 2	**Identify and formulate** an expression for complex aircraft structural problems using governing equations with ANSYS.	2
	PO 3	**Design and develop** a solution for various stress-strain distribution that are occured in the aircraft structure to meet the specified needs with appropriate consideration.	2
	PO 4	**Knowledge and understanding** the basic processes to **conduct investigations of complex problems** in the design of aircraft structural components to **provide numerical solution** in order to minimize the error.	3
	PO 5	Make use of **modern tools (ANSYS)** to create, select and apply the techniques for identifying the stress-strain values of aircraft components.	3
	PO 9	Resolve the aircraft wing, fuselage, and landing gear stress-strain distribution values using appropriate techniques and identify the effective solutions either by **individually or team work**.	3
	PO 10	By using the **communication and report writing skills** to generate an effective engineering report.	2
	PO 12	Apply the skills learnt in the ANSYS lab to identify the solutions for **real life problems** using suitable Workbench	3
	PSO 3	Make a use of **multi physics and computational methods** for bulding the career paths towards employability and higher studies.	3

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

Course Outcomes	Program Outcomes							PSO'S
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 9	PO10	PO12	PSO 3
CO 1	3	2	3	1	3	3	2	3	3
CO 2	3	2	3	3	3	3	2	3	3
CO 3	3	2	2	3	3	3	2	3	2
CO 4	3	2	3	3	3	3	2	2	3
CO 5	3	2	2	3	3	3	2	3	2
CO 6	3	2	2	3	3	3	2	3	3

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**INTRODUCTION AND BASIC FUNCTIONS**
	Starting up of ANSYS/NASTRAN. Description of user interface.
WEEK II	**STATIC ANALYSIS: TRUSSES AND FRAMES STRUCTURES**
	2D truss structures 3D truss structures
WEEK III	**STATIC ANALYSIS: BEAMS**
	Straight Beams Tapered Beams
WEEK IV	**STATIC ANALYSIS: TWO DIMENSIONAL PROBLEMS**
	2D Structure with various loadings 2D Structure with various materials Plate with a hole

WEEK V	**DYNAMIC ANALYSIS: MODAL AND TRANSIENT ANALYSIS**
	Modal analysis. Transient Response of spring mass system.
WEEK VI	**THERMAL ANALYSIS**
	Bars and Beams. 2D Structures.
WEEK VII	**NONLINEAR ANALYSIS**
	Non-linear behavior (large deflections) Non-linear behavior (materials)
WEEK VIII	**HARMONIC RESPONSE ANALYSIS**
	Random Vibration Analysis of a deep simply-supported beam. Harmonic response of a spring-mass system
WEEK IX	**ANALYSIS OF AIRCRAFT STRUCTURE : WING**
	Static analysis of aircraft wing structure. Modal analysis of aircraft wing structure.
WEEK X	**ANALYSIS OF AIRCRAFT STRUCTURE: FUSELAGE**
	Static analysis of aircraft semi monoque fuselage structure. Modal analysis of aircraft semi monoque fuselage structure.
WEEK XI	**ANALYSIS OF AIRCRAFT STRUCTURE: LANDING GEAR**
	Static analysis of aircraft landing gear. Modal analysis of aircraft landing gear.
WEEK XII	**ANALYSIS OF COMPOSITE STRUCTURES**
	Static analysis of composite bar and beam. Modal analysis of composite plate.

TEXTBOOKS

1. Huei-Huang Lee, —Finite Element Simulations with ANSYS Workbench 16‖, SDC publications, 2 nd Edition, 2016.
2. Anderson, William J —MSC/Nastran: Interactive Training Program‖ Wiley 1 st Edition 2015

REFERENCE BOOKS:

1. Huei-Huang Lee, —Finite Element Simulations with ANSYS Workbench 16‖, SDC publications, 2nd Edition, 2016.
2. Anderson, William J —MSC/Nastran: Interactive Training Program‖ Wiley 1 st Edition 2015.

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Introduction to simulation software.	CO 1	R1: 1.2
2	Introduction to ANSYS.	CO 1	R2: 3.5
3	Verification of Bernoulli's theorem.	CO 1	R1: 3.4
4	Determination of 2-D, 3-D truss structures.	CO 2	R1: 2.2

5	Determine the static-structural analysis.	CO 2	R1: 2.4
6	Determine the Structural analysis of beams under different load condition.	CO 3	R2: 4.5
7	Determine the model analysis of beams and spring-mass system.	CO 3	R2: 4.6
8	Determine the non-linear analysis for large deflections.	CO 4	R2: 5.1
9	Determine the harmonic response analysis of simply-supported beam.	CO 5	R2: 5.2
10	Determine the harmonic response analysis of a spring-mass system	CO 5	R1: 7.1
11	Determine the structural analysis of aircraft wings, fuselage, and landing gear	CO 6	R1:7.2
12	Determine the analysis of composite structures	CO 6	R1:7.3

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Uni-axial tensile** tests of different aircraft grade metals.
2	**Uni-axial compression** tests of different aircraft grade metals.
3	**Three-point bending** tests of a simply supported beam.
4	**Bending** of a cantilever beam.
5	**Harmonic vibration** of a beam

Signature of Course Coordinator **HOD,AE**
Mr. Gooty Rohan, Assistant Professor

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

Department	**Mechanical Engineering**				
Course Title	**Robotics**				
Course Code	AME533				
Program	B.Tech				
Semester	VII				
Course Type	Professional Elective				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	3	-	-
Course Coordinator	Mr. A. Anudeep Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS002	I	Linear Algebra and Ordinary Differential Equations
B.Tech	AME002	II	Engineering Mechanics

II OURSE OVERVIEW:

Robotics is recognized as one of the important aids of mechatronics systems and provides applications in the unmanned areas of industrial automation. The course emphasis on the design and developments of robot geometry, sensors and actuators to meet the kinematics requirements and trajectory planning of the manipulator. The overall applications in the manufacturing automation is to minimal elimination of human intervention.

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

Quiz - Online Examination

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

Alternative Assessment Tool (AAT)

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

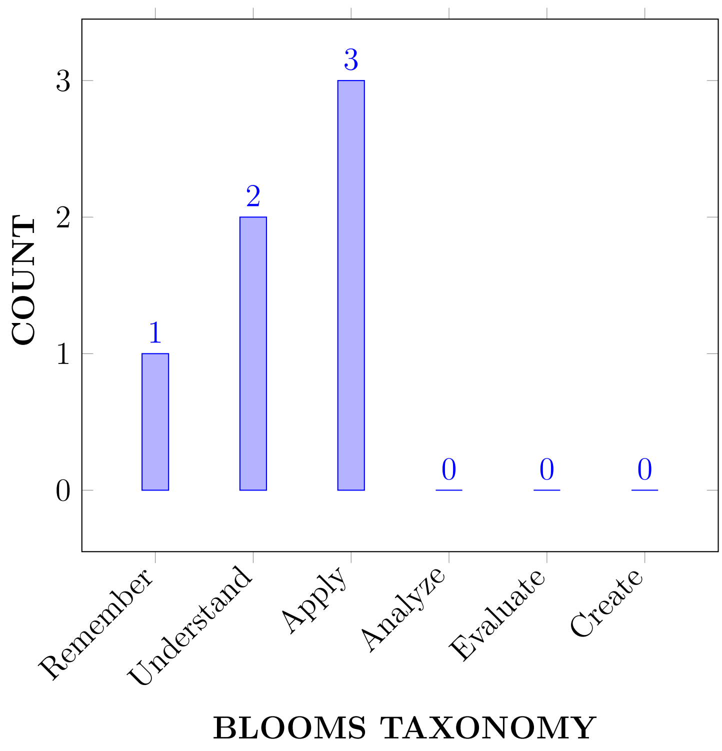
I	The fundamental concepts of various configurations of the robot manipulators and their working principles used in the industries.
II	The circuit design and operation for generation of high DC, AC and impulse voltages.
III	The path planning of a robot manipulator for given polynomial equation and how to avoid obstacles in its path.
IV	The performance of various feedback components like sensors and actuators and how they can be used according to the specifications of the manipulator.

VII COURSE OUTCOMES:

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

CO 1	**Outline** the relationship between mechanical structures of industrial robots and their operational workspace characteristics.	Understand
CO 2	**Demonstrate** an ability to apply spatial transformation to obtain forward kinematics equation of robot manipulators.	Apply
CO 3	**Develop** the mechanism for solving forward and inverse kinematics of simple robot manipulators.	Apply
CO 4	**Develop** an ability to obtain the Jacobian matrix and use it to identify singularities.	Apply
CO 5	**Outline** the various motions of the manipulator and use it for trajectory.	Understand
CO 6	**Illustrate** the considerations of workspace for a given robot application.	Remember

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program	
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	1	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety,and the cultural, societal, and Environmental considerations	2	CIE/Quiz/AAT

PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of computational and experimental tools for building career paths towards innovative start-ups, employability and higher studies.	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		
	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 OUT COMES	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 robotics and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and physics and **engineering fundamentals**.	2

CO 2	**PO 1**	Recall (knowledge) the basic steps involved in robotics and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and physics and engineering fundamentals.	2
	PO 2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design.	3
CO 3	**PO 4**	Investigate prototype models based on constraint including Environmental sustainability, Health and safety risks assessment issues and define specific problem.	2
CO 4	**PO 3**	Design the solution for problems of voltage doublers and multiplier circuits	3
CO 5	**PO 2**	Make use of the metal forming techniques used in Design, Model Creation and Validation of component Parts by Problem Analysis.	4
	PO 3	Understand the given problem statement related to their working principle and based upon type of robotics.	2
	PSO 3	Build practical experience in building the real time products, using automation.	2
CO 6	**PO 1**	Apply the basic mathematical principles used in formulation of engineering problems.	2
	PO 2	Understand the working principle used in robotics for trajectory planning.	2
	PSO 3	Identify the principle involved in robot actutators for varied applications.	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	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	4	2	-	-	-	-	-	-	-	-	-	-	-	2
CO 6	2	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	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	66.7	30.0	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	18.18	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	30.0	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	40.0	20.0	-	-	-	-	-	-	-	-	-	-	-	100.0
CO 6	66.7	20.0	-	-	-	-	-	-	-	-	-	-	-	-	100.0

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
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	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	1	2	-	-	-	-	-	-	-	-	-	-	-	3
CO 6	3	1	-	-	-	-	-	-	-	-	-	-	-	-	3
TOTAL	9	3	4	1	-	-	-	-	-	-	-	-	-	-	6
AVERAGE	3.0	1.0	2.0	1.0	-	-	-	-	-	-	-	-	-	-	3.0

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1,PO 2	SEE Exams	PO 1,PO 2, PO 3	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 1,PO 2 ,PO 4	Open Ended Experiments	-
Assignments	PO 1,PO 2, PO 3	Tech Talk	PO 4	-	-

XVII ASSESSMENT METHODOLOGY INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO AUTOMATION AND ROBOTICS**
	Introduction: Automation and robotic, an over view of robotics, classification by coordinate system and control systems, components of the industrial robotics: Degrees of freedom, end effectors: mechanical gripper, magnetic vacuum cup and other types of grippers, general consideration on gripper selection and design, robot actuator and sensors.
MODULE II	**MOTION ANALYSIS**
	Motion analysis: Basic rotation matrices, composite rotation matrices, equivalent angle and axis homogeneous transformation, problems; Manipulator kinematics: D-H notations, joint coordinates and world coordinates, forward and inverse kinematics, problems.
MODULE III	**DIFFERENTIAL KINEMATICS**
	Differential kinematics: Differential kinematics of planar and spherical manipulators, Jacobians problems. Robot dynamics: Lagrange, Euler formulations, Newton-Euler formulations, problems on planar two link manipulators.
MODULE IV	**TRAJECTORY PLANNING**
	Trajectory planning: Joint space scheme, cubic polynomial fit, avoidance of obstacles, types of motion: Slew motion, joint interpolated motion, straight line motion, problems, robot actuators and feedback components; actuators: pneumatic.
MODULE V	**ROBOTIC APPLICATIONS**
	Robot application in manufacturing: Material handling, assembly and inspection, work cell design.

TEXTBOOKS

1. M. P. Groover, "Industrial Robotics", Pearson, 2nd Edition, 2012.
2. J.J Criag, "Introduction to Robotic Mechanics and Control", Pearson, 3rd Edition, 2013.

REFERENCE BOOKS:

1. K.S Fu, "Robotics", McGraw-Hill, 1st Edition, 2013.
2. Richard, D. Klafter, Thomas A Chmielewski, Miachael Neigen, "Robotic Engineering An Integrated Approach", Prentice Hall, 1st Edition, 2013.
3. Asada, Slotine, "Robot Analysis and Intelligence", Wiley, 1st Edition, 2013.

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
	Introduction to Outcome Based Education		
1	Introduction to Automation and Robotics.	CO 1	T1:1.1
2	Determination of Kinematics of robot.	CO 2	T1:2.2
3	Determination of Dynamics of robot.	CO 3	T1:3.1
4	Trajectory path of manipulator and its importance.	CO 4	T1:4.1
5	Applications of robot in industtries.	CO 6	T1:5.1
CONTENT DELIVERY (THEORY)			
S.No	**Topics to be covered**	**CO's**	**Reference**
6	Introduction to automation.	CO 1	T1:1.1
7	Classification of automation and its role.	CO 1	T1:1.1
8	Introduction to robotics.	CO 1	T1:1.2
9	Need of automation and robotics in manufacturing.	CO 1	T1:1.3
10	Degrees of freedom and its classification.	CO 1	T1:1.4
11	Classification of robots based on degrees of freedom and control.	CO 1	T1:1.5
12	Description of Robot Components.	CO 1	T1:1.6
13	Classification of robot end effectors.	CO 1	T1:1.7
14	Gripper force calculation.	CO 1	T1:1.8
15	Requirement of gripper selection features.	CO 1	T1:1.9
16	Classification of robot actuators.	CO 1	T1:1.10
17	Classification of robot sensors.	CO 1	T1:1.11
18	Introduction to robot motion analysis.	CO 2	T1:2.1
19	Manipulator rotational matrices.	CO 2	T1:2.2
20	Composite rotation matrices, equivalent angle .	CO 2	T1:2.3
21	Homogeneous transformations of the manipulator.	CO 2	T1:2.4
22	Joint space coordinates and world space coordinates.	CO 2	T1:2.5
23	Introduction to Manipulator kinematics.	CO 2	T1:2.6
PROBLEM SOLVING/ CASE STUDIES			
24	Forward kinematics of 2 D.O.F in 2D and 3D.	CO 2	T1:2.7
25	Forward kinematics of 3 D.O.F in 2D and 3D.	CO 2	T1:2.8
26	Inverse kinematics of 2 D.O.F in 2D and 3D.	CO 2	T2:2.9
27	Inverse kinematics of 3 D.O.F in 2D and 3D.	CO 2	T2:2.10
28	Denavit-Hartenberg notation of the manipulator.	CO 2	T2:2.11
29	Problems related to transformation of manipulator in various axes.	CO 2	T2:2.12
30	Derivation of Lagrange-Euler equation and solution of problems different configuration of robots	CO 3	R2:3.1
31	Derivation of Lagrange-Euler equation and solution of problems different configuration of robots	CO 3	R2:3.1

32	Derivation of Newton-Euler equation and solution of problems different configuration of robots.	CO 3	R2:3.2
33	Derivation of Newton-Euler equation and solution of problems different configuration of robots.	CO 3	R2:3.2
34	Problems on differential motion derivation of jacobian matrix for various configuration.	CO 3	R2:3.3
35	Problems on planar two link manipulators.	CO 4	R2:3.4
36	Introduction to trajectory planning.	CO 4	R2:4.1
37	Illustration of Joint space motion for both straight line and point to point.	CO 5	R2:4.2
38	Illustration of slew motion and interpolated motion.	CO 5	R2:4.3
39	Explanation of polynomial equation for various types of motion and solution of Problems in various types of trajectories.	CO 5	R2:4.4
40	Cubic polynomial fit of the trajectory.	CO 5	R2:4.5
41	Solving of problems on cubic polynomial fit.	CO 5	R2:4.6
42	Avoidance of obstacles in robot path.	CO 5	R2:4.7
DISCUSSION OF DEFINITION AND TERMINOLOGY			
43	Classification of robot actuators.	CO 5	R1:4.8
44	Description of Hydraulic actuators.	CO 5	R2:4.9
45	Description of Pneumatic actuators.	CO 5	R2:4.10
46	Description of Electric actuators.	CO 5	R2:4.11
47	Classification of feedback components.	CO 5	R2:4.12
48	Classification of feedback components.	CO 5	R2:4.13
49	Function wise description of various configuration of robots for different applications	CO 6	T1:5.1
50	Function wise description of various configuration of robots for different applications	CO 6	T1:5.2
51	Role of robots in material handling.	CO 6	T1:5.3
52	Role of robots in material handling.	CO 6	T1:5.4
53	Applications of robots in manufacturing.	CO 6	T1:5.5
54	Applications of robots in manufacturing.	CO 6	T1:5.6
DISCUSSION OF QUESTION BANK			
55	Description of robot work cell design of the robot.	CO 6	T1:5.7
56	Description of robot work cell design of the robot.	CO 6	T1:5.8
57	Palletizing by the robot.	CO 6	T1:5.9
58	Machine loading and unloading using the robot.	CO 6	T1:5.9
59	Part selection and transfer using the robot.	CO 6	T1:5.10
60	Robots in assembly operations.	CO 6	T1:5.11

Signature of Course Coordinator **HOD,MECH**
Mr.A. Anudeep Kumar, Assistant Professor

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

COURSE DESCRIPTION

Department	**Aeronanutical Engineering**				
Course Title	**Computational Aerodynamics**				
Course Code	AAE013				
Program	B.Tech				
Semester	VI				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. Athota Rathan Babu, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAE003	III	Fluid Mechanics and Hydraulics
B.Tech	AAE004	IV	Low Speed Aerodynamics
B.Tech	AAE008	V	High Speed Aerodynamics

II COURSE OVERVIEW:

Computational aerodynamics is the study of computational analysis on aerodynamic flow bodies. This course deals with the basic aspects of Computational Fluid Dynamics, emphasizing on the governing equations of fluid dynamics and their numerical discretization techniques using finite volume and finite difference methods. The course also discusses the methods of grid generation techniques for both structured and unstructured grid in 2D as well as 3D. It describes the mathematical behavior of the different classes of partial differential equations, this deal with pressure based solvers for incompressible viscous flow.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Computational Aerodynamics	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1.

Percentage of Cognitive Level	Blooms Taxonomy Level
0 %	Remember
17 %	Understand
83 %	Apply
0 %	Analyze
0 %	Evaluate
0 %	Create

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	The concepts of grid generation techniques for simple and complex domains to model fluid flow problems.

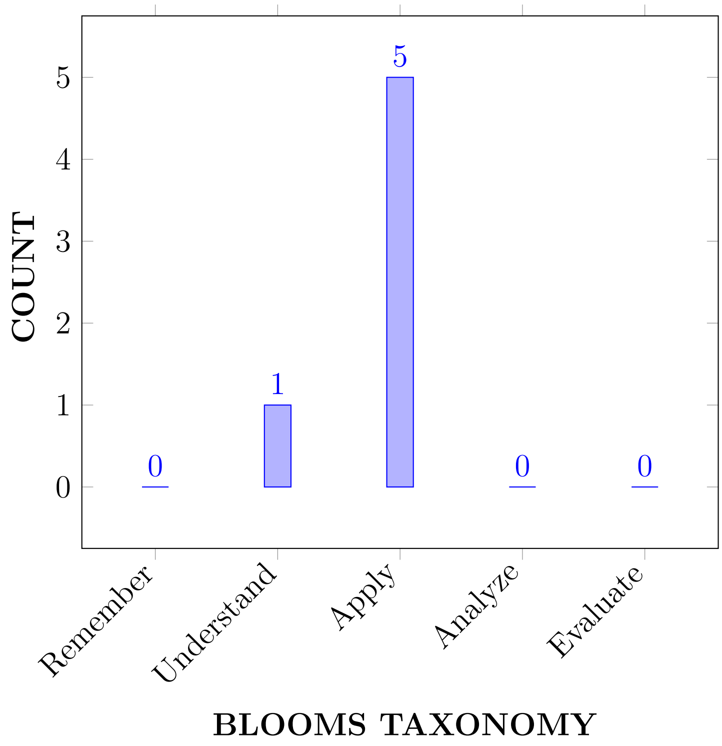
II	The aspects of numerical discretization techniques such as finite volume and finite difference methods.
III	The mathematical modeling of different classes of partial differential equations to show their impact on computational fluid dynamics.
IV	The characteristics of different turbulence models and numerical schemes for estimating the criteria of stability, convergence, and error of fluid flow problem.

VII COURSE OUTCOMES:

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

CO 1	**Summarize** the concepts of computational fluid dynamics and its applications in industries as a tool for fluid analysis.	Understand
CO 2	**Choose** the type of flow from the finite control volume and infinitesimal small fluid element for the fluid flow analysis.	Apply
CO 3	**Select** the quasi linear partial differential equation for estimating the behavior in computational fluid dynamics.	Apply
CO 4	**Identify** CFD techniques for relevant partial differential equations for getting analytical solutions for fluid flow problems.	Apply
CO 5	**Make use of** finite difference approach for numerical formulations based on fluid mechanics and heat transfer concepts for getting the solutions of fluid flow problems.	Apply
CO 6	**Utilize** the grid generation and transformation techniques in implementation of finite difference and finite volume methods in solving complex fluid and aerodynamic problems.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	CIE/Quiz/AAT
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	2	CIE/Quiz/AAT
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	3	CIE/Quiz/AAT
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical including air traffic controls standards.	2	Research papers/ Group discussion/ Short term courses
PSO 3	Make use of design, computational and experimental tools for research and innovation in aerospace technologies and allied streams, to become successful professionals, entrepreneurs and desire higher studies.	2	Research papers/ Group discussion/ Short term courses

3 = High; 2 = Medium; 1 = Low

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

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Summarize the history, basics of computational fluid dynamics (Knowledge) and its importance in solving complex **engineering problems** by applying partial differentials **mathematics** and fundamentals of engineering and fluid sciences.	3
	PO 2	**Select the type of flow based on control volume** analysis by basic partial differentials (mathematics) and fluid sciences.	2
	PO 3	**Identify appropriate finite difference methods for numerical formulations** from the fundamentals of mathematics and engineering fluid thermal sciences.	3
	PO 4	Understand the given fluid flow problem and formulate the appropriate CFD technique **by using first principles of mathematics (Partial differential equations) to get analytical solutions** in order to validate results.	2
	PO 7	Understand the customer requirement, identify the proper finite volume method for **complex thermal systems used in various applications**.	2
CO 2	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** and derive the governing equations under different conditions	3
	PO 2	**Identify and Understand** the given fluid flow problem and formulate the appropriate CFD technique by using first principles of mathematics (Partial differential equations) to get analytical solutions in order to validate results.	2
	PO 3	**Formulate the problem statement and identify** the suitable finite difference method to obtain substantiated conclusions by the interpretation of results.	3
	PO 6	**Understand the customer requirement, identify** the proper finite volume method for complex thermal systems used in various applications.	2
	PO 10	Identify the available partial differential equations (analytical methods) for **engineering fluid flow problems and apply** computer software (CFD) to provide solutions by analyzing the processes.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 1	**Illustrate the quasi linear partial differential equation** to physical systems in design of fluid thermal systems to provide solutions in interdisciplinary applications.	2
CO 3	PO 1	Apply the knowledge of mathematics, science, engineering fundamentals to illustrate the quasi linear partial differential equations **using principles of mathematics, science, and engineering fundamentals.**	3
	PO 3	Analyze the performance parameters of CFD techniques and various schemes used on CFD models using **first principles of Mathematics and engineering sciences.**	3
	PO 4	Identify the available partial differential equations (analytical methods) for engineering fluid flow problems and apply computer software (CFD) to provide solutions by analyzing the processes.	2
	PO 7	Select the necessary discretization methods to analyse the stability of fluid system in the aspect of design the problems experimentally and numerically to recognize the significance of them in solving various engineering problems and creating solutions for thermal systems.	2
	PO 12	Apply appropriate finite volume technique to solve the complex thermal problems.	2
	PSO 3	Build various methods of grid generation techniques for Designability of physical systems into mathematical formulations with Sustainable designs	2
CO 4	PO 1	**Analyse** the different discretization methods for solving thermal problems by using **engineering fundamentals in fluid sciences using mathematical equations** (partial differential equations) to minimise the errors.	3
	PO 2	**Identify, define the necessary discretization** methods to analyse the stability of fluid system in the aspect of design the problems experimentally and numerically to recognize the significance of them in solving various engineering problems and creating solutions for thermal systems.	2
	PO 4	Knowledge and understanding the basic processes to **conduct investigations of complex problems in the design, analysis** to provide numerical solution in order to minimise the error.	2
	PSO 1	**Identify** the available partial differential equations for engineering fluid flow problems and apply computer software (CFD) to provide **solutions by analyzing the processes**.	2
CO 5	PO 1	Select appropriate finite difference methods for numerical formulations from the fundamentals of mathematics and engineering **fluid thermal sciences.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 3	**Understand** the given fluid flow problem and formulate the appropriate CFD technique by using first principles of mathematics (Partial differential equations) and **approriate numerical techniques to get solutions and validate results.**	3
	PO 5	**Select an appropriate technique of finite volume methods** to solve the fluid flow of real world problems.	2
	PO 12	**Build up (Apply) the skills** in the actual implementation of CFD methods in industry trends based on advanced engineering concepts.	2
	PSO 1	Analyze the performance parameters of CFD techniques and various schemes used on CFD models using **first principles of Mathematics and engineering sciences.**	2
	PSO 3	**Make use of computational techniques** and simulation methods for the analysis of fluid problems in the career path of **modern engineering start up industries**.	2
CO 6	PO 1	Distinguish various methods of grid generation techniques in the design of complex problems by using **fundamental knowledge of fluid science and engineering** to evolve relationships using partial derivative **mathematical functions**	3
	PO 2	**Understand the customer requirement, identify the** proper finite volume method for complex thermal systems used in various applications	2
	PO 3	**Build up the appropriate techniques** for prediction and modelling the fluid flow and heat transfer problems by using modern engineering tools and simulation techniques with an understanding of limitations.	3
	PO 4	Recognize (Knowledge) the characteristics of various fluid flow processes, understand the corresponding the context of **engineering knowledge related to different methods** of CFD and analyse the basic parameters influencing the flow by incorporating commercial CFD codes.	2
	PO 10	**Apply the skills in the actual implementation** of CFD methods in advanced industry trends based on engineering concepts.	3
	PSO 1	Illustrate the quasi linear partial differential equation to design tools for scale down models and **technologies for development of high efficiency**.	2

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	20	20	18	-	-	66	-	-	-	-		-	-	-
CO 2	100	20	20	-	-	40	-	-	-	60	-	-	50	-	-
CO 3	100	-	30	18	-	-	66	-	-	-	-	25	-	-	50
CO 4	100	20	-	18	-	-	-	-	-	-	-		50	-	-
CO 5	100	-	30	-	100	-	-	-	-	-	-	25	50	-	50
CO 6	100	20	30	18	-	-	-	-	-	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	1	1	1	-	-	3	-	-	-	-		-	-	-
CO 2	3	1	1	-	-	1	-	-	-	3	-	-	2	-	-
CO 3	3	-	1	1	-	-	3	-	-	-	-	1	-	-	2
CO 4	3	1	-	1	-	-	-	-	-	-	-		2	-	-
CO 5	3	-	1	-	3	-	-	-	-	-	-	1	2	-	2
CO 6	3	1	1	1	-	-	-	-	-	3	-		2	-	-
TOTAL	18	4	5	4	3	1	6	-	-	6	-	2	8	-	4
AVERAGE	3	1	1	1	3	1	3	-	-	3	-	1	2	-	2

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION**
	Need of computational fluid dynamics, philosophy of CFD, CFD as a research tool as a design tool, applications in various branches of engineering, models of fluid flow finite control volume, infinitesimal fluid element, substantial derivative physical meaning of divergence of velocity, derivation of continuity, momentum and energy equations, physical boundary conditions significance of conservation and non-conservation forms and their implication on CFD applications strong and weak conservation forms shock capturing and shock fitting approaches.
MODULE II	**MATHEMATICAL BEHAVIOR OF PARTIAL DIFFERENTIAL EQUATIONS AND THEIR IMPACT ON COMPUTATIONAL AERODYNAMICS**
	Classification of quasi-linear partial differential equations by Cramer‘s rule and Eigen value method, general behavior of different classes of partial differential equations and their importance in understanding physical and CFD aspects of aerodynamic problems at different Mach numbers involving hyperbolic, parabolic and elliptic equations: domain of dependence and range of influence for hyperbolic equations, well-posed problems.
MODULE III	**BASIC ASPECTS OF DISCRETIZATION**
	Introduction to finite difference: finite difference approximation for first order, second order and mixed derivatives, explicit and implicit approaches, truncation and round-off errors, consistency, stability, accuracy, convergence, efficiency of numerical solutions. Von Neumann stability analysis, physical significance of CFL stability condition. Need for grid generation, structured grids artesian grids, stretched (compressed) grids, body fitted structured grids, H-mesh, C-mesh, O-mesh, I-mesh, multi-block grids, C-H mesh, H-O-H mesh, overset grids, adaptive grids, unstructured grids: triangular, tetrahedral cells, hybrid grids, quadrilateral, hexahedral cells.

MODULE IV	**CFD TECHNIQUES**
	Lax-Wendroff technique, MacCormack's technique, Crank Nicholson technique, Relaxation technique, aspects of numerical dissipation and dispersion. Alternating-Direction-Implicit (ADI) Technique, pressure correction technique: application to incompressible viscous flow, need for staggered grid. Philosophy of pressure correction method, pressure correction formula. Numerical procedures: SIMPLE, SIMPLER, SIMPLEC and PISO algorithms, boundary conditions for the pressure correction method.
MODULE V	**FINITE VOLUME METHODS**
	Basis of finite volume method, conditions on the finite volume selections, cell-centered and cell vertex approaches. Definition of finite volume discretization, general formulation of a numerical scheme, two dimensional finite volume methods with example.

TEXTBOOKS

1. J. D. Anderson, Jr., "Computational Fluid Dynamics - The Basics with Applications", Mc Graw Hill Inc, 2012.

2. D A Anderson, J C Tannehill, R H Pletcher, "Computational Fluid Mechanics and Heat Transfer", 1st edition, 1997.

REFERENCE BOOKS:

1. Hirsch, C., "Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics", Vol. I, Butter worth-Heinemann, 2nd edition, 2007.

2. Hoffmann, K. A. and Chiang, S. T., "Computational Fluid Dynamics for Engineers", Engineering Education Systems, 4th edition, 2000.

3. Patankar, S.V., "Numerical Heat Transfer and Fluid Flow", Hemisphere Pub. Corporation, 1st edition, 1980.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112/105/112105045/

2. https://nptel.ac.in/courses/112/106/112106294/

3. https://ocw.mit.edu/courses/mechanical-engineering/2-29-numerical-fluid-mechanics-spring-2015/lecture-notes-and-references/

COURSE WEB PAGE:

1. https://www.iare.ac.in/sites/default/files/R18/Computational_Aerodynamics.pdf

2. https://lms.iare.ac.in/index?route=course/details&course_id=455

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	-
CONTENT DELIVERY (THEORY)			
1	Computational Fluid Dynamics Introduction CFD is a Research tool, as a design tool	CO 1, CO 2	T2: 1.1-1.5, T1: 4.1
2	Applications of CFD in various branches of engineering.	CO 1	T2: 2.1-2.2, R1: 3.1
3	Models of fluid flow, Finite Control Volume Infinitesimal Fluid Element	CO 1	T2: 2.3-2.4
4	Substantial derivative, Physical meaning of Divergence of velocity	CO 1	T2: 2.5-2.6,
5	Continuty equation derivation and its physical significance	CO 1	T2: 3.3
6	Momentum equation derivation and its physical significance	CO 2	T2: 3.4
7	Energy equation derivation and its physical significance	CO 2	T2: 3.3
8	Physical Boundary Conditions, Significance of conservation form and their implication on CFD applications	CO 2	T2: 4.2
9	Significance of non-conservation form and their implication on CFD applications	CO 3	T2: 5.1
10	Strong and weak conservation forms	CO 3	T2: 5.2
11	Shock capturing and shock fitting approaches.	CO 1	T2: 4.5
12	Classification of quasi-linear partial differential equations by Cramer's rule method	CO 1	T1: 4.1
13	Classification of quasi-linear partial differential equations by Eigen value method	CO 3	T1: 4.2
14	General behaviour of different classes of partial differential equations.	CO 4	T1: 4.3
15	Similarity parameters: geometric, kinematic and dynamic similarity	CO 5	T2: 5.2
16	Partial different equations importance in understanding physical and CFD aspects of aerodynamic problems.	CO 5	T1 : 4.3
17	Methods of describing fluid motion:Lagragian and Eulerian approach	CO 5	T2: 5.2
18	Types of fluid flows and their mathematical formulation	CO 6	T1: 7.2
19	Different Mach numbers involving hyperbolic, parabolic and elliptic equations	CO 6	T1: 7.5
20	Dependence and range of influence for hyperbolic equations, Well-posed problems	CO 5	T1: 7.5

21	Introduction to Finite Difference approximation for first order derivatives.	CO 5	R2:7.5
22	Finite difference approximation for second order derivatives.	CO 6	R2:7.5
23	Finite difference approximation for mixed derivatives.	CO 5	R2:7.5
24	Explicit approaches, Pros and cons of higher order difference schemes	CO 5	R2:7.5
25	Implicit approaches, Pros and cons of higher order difference schemes	CO 5	T1 : 4.4
26	Difference equations- explicit and implicit approaches, Pros and cons of higher order difference schemes	CO 4	T2 : 3.3.1- 3.3.4
27	Truncation and round-off errors, consistency, stability, accuracy, convergence.	CO 4	T1 : 4.5
28	Von Neumann stability analysis Physical significance of CFL stability condition.	CO 4	R1 : 6.1
29	Need for grid generation Structured grids	CO 4	R1 : 6.1.1, 6.1.3
30	Cartesian grids stretched (compressed) grids body fitted structured grids, H-mesh, C-mesh, O-mesh, I-mesh.	CO 4	R1 : 6.1.3, 6.1.4
31	Multi-block grids, C-H mesh, H-O-H mesh, overset grids	CO 4	R1 : 6.2/ R4 : 11.6
32	Adaptive grids, Unstructured grids Triangular/ tetrahedral cells, hybrid grids Quadrilateral/ hexahedra cells	CO 4	T1 : 6.5, 6.6, 6.7
33	Lax-Wendroff technique, Mac Cormack's technique Crank Nicholson technique.	CO 4	T1 : 6.8
34	Relaxation technique, aspects of numerical dissipation and dispersion.	CO 5	T1 : 6.8.2, 6.8.3 / R3 :6.6
35	Alternating Direction Implicit Technique, Pressure correction technique- application to incompressible viscous flow.	CO 5	T1 : 2.3, 2.4
36	Need for staggered grid. Philosophy of pressure correction method, Pressure correction formula	CO 5	R2:7.5
37	Numerical procedures, SIMPLE and SIMPLER algorithms, SIMPLEC and PISO algorithms	CO 4	R1 : 6.1
38	Boundary conditions for the pressure correction method, Basis of finite volume method conditions on the finite volume selections.	CO 5	T1 : 6.5, 6.6, 6.7
39	Cell-centered and cell-vertex approaches, Definition of finite volume discretization General formulation of a numerical scheme.	CO 6	R1 : 6.1.1, 6.1.3
40	3-dimensional finite volume method with convection and diffusion problem.	CO 6	T1 : 6.8.2, 6.8.3 / R3 :6.6

PROBLEM SOLVING/ CASE STUDIES			
1	Explain how the continuity equation derived from these flow models can be converted from conservative to non-conservative form.	CO 1	T2:5.6 R1:1.12.3
2	Explain and Differentiate shock fitting and shock capturing methods with the suitable diagram.	CO 1	T2:5.6 R1:1.12.3
3	Illustrate the non-conservative form of governing equations. Derive continuity equation in non-conservation form using infinitesimal small fluid element moving in space.	CO 1	T2:5.6 R1:1.12.3
4	Explain the mathematical and physical nature of flows governed by parabolic Equations with an illustration of a steady boundary layer flow.	CO 1	T2:5.10 R1:1.15
5	Explore the boundary layer flow for the parabolic equation by considering the nose region with the neat sketch.	CO 2	T2:5.18 R2:1.13.2
6	Explicit the general behavior of the different classes of partial differential equation – impact on physical and computational fluid dynamics with suitable example for each.	CO 2	T2:5.20 R1:1.17.1
7	Elucidate the domain and boundaries for the solution of hyperbolic equations for the three dimensional steady flow.	CO 3	T2:6.3 R1:2.6.1
8	Discuss the domain and boundaries for the solution of hyperbolic equations for the one and two dimensional unsteady flow with the suitable diagram.	CO 3	T2:6.3 R1:2.6.1
9	Illustrate the physical behavior of flows governed by hyperbolic equations with an example of steady, inviscid supersonic flow over a two dimensional circular arc airfoil.	CO 5	T2:6.5 R1:2.6.2
10	Illustrate the physical behavior of flows governed by parabolic equations with an example of steady boundary layer flows. Explain PNS model for high speed flows and explain its merits.	CO 5	T2:7.7 R1:2.10
11	Explain the Parabolized Navier-Stokes equations and well-posed problems.	CO 4	T2:7.7 R1:2.10
12	Write short notes on the following properties of numerical solutions of fluid flows: i) Stability ii) Consistency iii) Accuracy iv) Convergence.	CO 5	T2:7.11 R1:2.32
13	Illustrate the time marching solution for constructing the explicit finite difference module by considering one-dimensional heat conduction equation which is parabolic partial differential solution.	CO 4	T2:15.13 R1:8.7.2
14	Explain the difference equation by considering unsteady, one-dimensional heat conduction equation with constant thermal diffusivity with the neat sketch.	CO 6	T2:5.20 R1:1.17.1
15	Illustrate a stable case by comparing the numerical domain include the entire analytical domain and does not include the entire analytical domain with the neat sketch.	CO 6	T2:7.3 R1:2.8
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	What is Parabolized Navier-Stokes equation?	CO 1	T2:5.6 R1:1.12.3
2	What is Courant–Friedrichs–Lewy (CFL) condition?	CO 2	T2:5.18 R2:1.13.2

3	What is flux corrected transport method?	CO 4,5	T2:6.5 R1:2.6.2
4	What is Time-dependent density functional theory?	CO 5	T2:7.11 R2:2.10.2
5	What is convection–diffusion equation?	CO 5	T2:6.3 R3:2.6.1
DISCUSSION OF QUESTION BANK			
1	Continuity, Momentum and Energy equations with significance of conservation and non-conservation forms and their implication on CFD applications	CO 1,2,3	T2:5.10 R1:1.15
2	CFD aspects of aerodynamic problems at different Mach numbers involving hyperbolic, parabolic and elliptic equations	CO 2,3	T2:6.1 R1:2.3
3	Von Neumann stability analysis and its physical significance of CFL stability condition	CO 4,5	T2:7.3 R1:2.8
4	Numerical procedures: SIMPLE, SIMPLER, SIMPLEC and PISO algorithms	CO 5,6	T2:7.11 R1:2.32
5	General formulation of a numerical scheme and a two dimensional finite volume methods with example	CO 4,6	T2:6.3 R3:2.6.1

Signature of Course Coordinator **HOD,AE**
Mr. A Rathan Babu Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

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

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

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

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

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

Signature of Course Coordinator **HOD,AE**

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**SPACE MECHANICS**				
Course Code	AAE016				
Program	B.Tech				
Semester	VII				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
Course Coordinator	Dr. Prasanta Kumar Mohanta, Professor				

I COURSE PRE-REQUISITES:

Level	**Course Code**	**Semester**	**Prerequisites**
B.Tech	AHS002	I	Linear Algebra and Ordinary Differential Equations
B.Tech	AHS011	III	Mathematical Transform Techniques

II COURSE OVERVIEW:

The space mechanics focuses on conceptual understanding of planetary and solar systems, spacecraft manoeuvres, propulsion and control systems used in mission design of launch vehicles and missiles. This subject motivates to gain knowledge of the challenges related to the use of the space environments, criterion of dominating perturbing forces as a platform for scientific and practical purposes. Also, this course emphasisfor optimising mission design for rockets and missiles.

III MARKS DISTRIBUTION:

Subject	**SEE Examination**	**CIE Examination**	**Total Marks**
Fluid Dynamics	75 Marks	25 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

textbfContinuous Internal Examination (CIE): Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - 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 everycourse.

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
35%	Apply
15%	Analyze

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 25 marks, with 20 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:

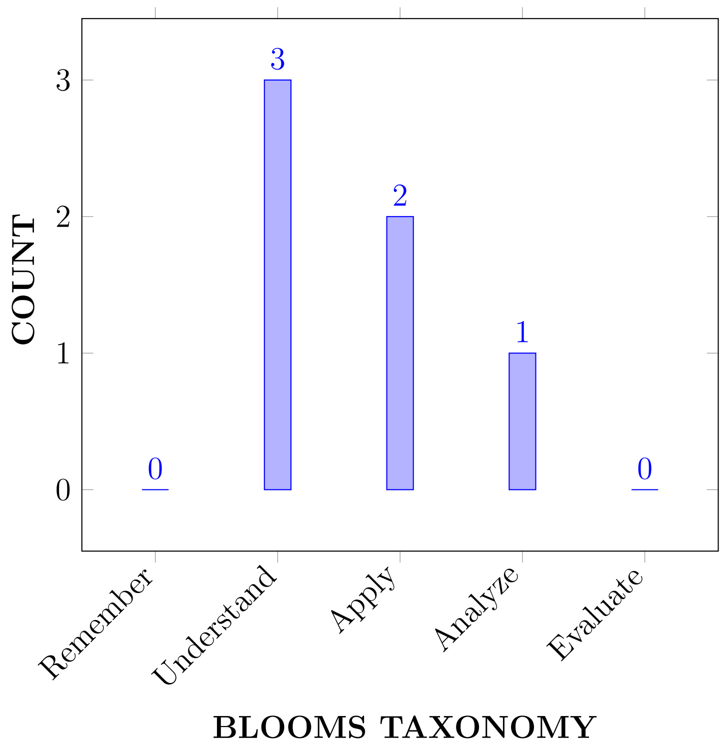
I	The knowledge in two-body, restricted three-body and n-body problem, Hamiltonian dynamics, canonical transformations, Poincare surface sections.
II	The characterization of orbital motions and their relations for evaluating the orbital parameters through transformations.
III	Provide necessary knowledge for understanding satellite and interplanetary trajectories and formal approaches for handling coordinate transformations
IV	The optimizing techniques for final mission of spacecrafts and missiles by using various methods.

VII COURSE OUTCOMES:

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

CO 1	**Utilise** the concepts of Solar system, Lagrange-Jacobi identity and N-body problem for determining the Lagrange points in the Earth Moon system.	Apply
CO2	**Demonstrate** the dependence of orbital parameters of orbit deviations using Orbital elements for Launch vehicle ascent trajectories	Understand
CO3	**Identify** the Equations of motion and characteristics of orbits using the relation between orbital elements and position for Launch vehicle performance.	Apply
CO4	**Classify** the 2-Dimensional, 3-Dimensional interplanetary trajectories and general perturbations in Cowell's Method for launching interplanetary spacecraft and identifying trajectory of the target planet.	Analyze
CO5	**Illustrate** the boost phase, ballistic phase and trajectory geometry using the techniques of Re-entry for Ballistic Missile Trajectories.	Understand
CO6	**Demonstrate** the mission performance parameters with help of constant radial thrust acceleration, constant tangential thrust for Low thrust trajectories.	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.

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

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

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Demonstrate solar system, reference frames, and coordinate systems through exact differentials using the knowledge of mathematics, science and engineering fundamental.	3
	PO2	Understand the celestial sphere, the ecliptic, a motion of vernal equinox, sidereal time, solar time, standard time, and the Earth's atmosphere by the fundamental laws of thermodynamics using the knowledge of engineering fundamentals and mathematics.	5
	PSO1	Discuss many body problem, and the Lagrange-Jacobi identity problems to real world systems and provide solutions for Space Mechanics problems.	1
CO 2	PO 1	Demonstrate the expansions in elliptic motion, and orbital elements. using the knowledge of mathematics, science and engineering fundamental.	3
	PO 2	Understand the relation between orbital elements and position and velocity vectors e by the fundamental laws of thermodynamics using the knowledge of engineering fundamentals and mathematics.	5
CO 3	PO 1	Demonstrate Orbital elements, launch vehicle accent trajectories and launch vehicle performance using the knowledge of mathematics, science and engineering fundamental.	3
CO 4	PO 1	Demonstrate the dependence of orbital parameters on in plane injection parameters, launch vehicle performances, and orbit deviations using the knowledge of mathematics, science and engineering fundamental.	3
	PSO1	Discuss Launch vehicle ascent trajectories problems to real world systems and provide solutions for motion for different orbits.	1
CO 5	PO 2	Understand the trajectory geometry, optimal flights. Time of flight, Re-entry phase by the fundamental laws of thermodynamics using the knowledge of engineering fundamentals and mathematics	5
	POS 1	Discuss Boost phase, ballistic phase and re-entry phase problems to real world systems and provide solutions for Ballistic Missile Trajectories.	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	PO2	Understand the 3D interplanetary trajectories by the fundamental laws of thermodynamics using the knowledge of engineering fundamentals and mathematics.	5
	POS 1	Discuss the 3D interplanetary trajectories for the launching of interplanetary spacecraft and identifying trajectory of the target planet problems to real world systems and provide solutions for Ballistic Missile Trajectories.	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	-	-	-	-	-	-	-	-	-		2	-	-
CO 2	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-		-	-	-	-	-	-		2	-	-
CO 5	-	4	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 6	-	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	50	-	-	-	-	-	-	-	-	-		100	-	-
CO 2	100	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	-	-	-		-	-	-	-	-	-		100	-	-
CO 5	-	40	-	-	-	-	-	-	-	-	-	-	100	-	-
CO 6	-	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	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 5	-	1	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 6	-	1	-	-	-	-	-	-	-	-	-	-	3	-	-
TOTAL	12	6	-	-	-	-	-	-	-	-	-	-	12	-	-
AVERAGE	2	1	-	-	-	-	-	-	-	-	-	-	2	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**Introduction to Space Mechanics**
	Basic concepts: The solar system, Reference frames and coordinate systems, The celestial sphere, The ecliptic, Motion of vernal equinox, Sidereal time, Solar Time, Standard Time, The earth's atmosphere.The many body problem, Lagrange-Jacobi identity. The circular restricted three body problem, Liberation points, Relative Motion in the N-body problem.
MODULE II	**Two Body Problem**
	Equations of motion-General characteristics of motion for different orbits-Relations between position and time for different orbits, Expansions in elliptic motion, Orbital Elements. Relation between orbital elements and position and velocity: Launch vehicle ascent trajectories, General aspects of satellite injection. Dependence of orbital parameters on in-plane injection parameters, Launch vehicle performances, Orbit deviations due to injection errors.
MODULE III	**Perturbed Satellite Orbit**
	Special and general perturbations-Cowell's Method, Encke's method. Method of variations of orbital elements, General perturbations approach. Two-dimensional interplanetary trajectories, Fast interplanetary trajectories, Three dimensional interplanetary trajectories. Launch of interplanetary spacecraft. Trajectory about the target planet.
MODULE IV	**Ballistic Missile Trajectories**

	The boost phase, the ballistic phase, Trajectory geometry, optimal flights. Time of flight, Re-entry phase. The position of the impact point, Influence coefficients.
MODULE V	**Low Thrust Trajectories**
	Equations of Motion. Constant radial thrust acceleration, Constant tangential thrust (Characteristics of the motion), Linearization of the equations of motion, Performance analysis.

TEXTBOOKS

1. J. W. Cornelisse, —Rocket Propulsion and Spaceflight Dynamics‖, Pitman Publishing, London, 1979

2. William E. Wiesel, —Spaceflight Dynamics‖, McGraw-Hill, 3rd Edition, New Delhi, 2010.

REFERENCE BOOKS:

1. Vladimir A. Chobotov, —Orbital Mechanics‖, AIAA Education Series, USA, 3rdEdition,2002.

2. Kaplan, Marshall H., —Modern Spacecraft Dynamics and Control‖, John Wiley & Sons, New York, 1976.

3. Wiesel, William E., —Spaceflight Dynamics‖, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2ndEdition 2007.

4. David A. Vellado, —Fundamentals of Astrodynamics and Applications‖, Springer, Germany, 3rdEdition, 2007

WEB REFERENCES:

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

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1			
CONTENT DELIVERY (THEORY)			
1	Basic concepts: The solar system.	CO 1	T2: 1.1
2	Reference frames and coordinate systems	CO 1	T1: 1.1-1.2
3	The celestial sphere, The ecliptic, Motion of vernal equinox, Sidereal time	CO 1	T2: 2.3-2.4
4	Solar Time, Standard Time, The earth's atmosphere.	CO1	T2: 2.5-2.6
5	The many body problem,	CO1	T2: 3.3
6	Lagrange-Jacobi identity	CO2	T2: 3.3

7	The circular restricted three body problem, Liberation points	CO 2	T2:3.4, R1: 4.1
8	Relative Motion in the N-body problem	CO2	T2 2-4
9	Equations of motion-General characteristics of motion for different orbits	CO 3	T2: 3.5
10	Relations between position and time for different orbits	CO 3	T2: 3.5
11	Expansions in elliptic motion	CO 3	T2: 3.3
12	Orbital Elements. Relation between orbital elements and position and velocity	CO 3	T2: 3.3
13	Launch vehicle ascent trajectories	CO 3	T2: 4.2
14	General aspects of satellite injection	CO 3	T2:4.3-4
15	Dependence of orbital parameters on in-plane injection parameters	CO 3	T2: 5.1
16	Launch vehicle performances	CO 3	T2:5.2
17	Orbit deviations due to injection errors.	CO 3	T2: 5.3
18	Special and general perturbations-Cowell's Method	CO4	T2: 5.4
19	Special and general perturbations-Cowell's Method, Encke's method.	CO4	T2: 5.5 R3: 3.2
20	Method of variations of orbital elements	CO4	T2:5.6
21	General perturbations approach	CO4	T1:4.5
22	Two-dimensional interplanetary trajectories	CO4	T2: 4.5
23	Fast interplanetary trajectories	CO4	T2: 4.6
24	Three dimensional interplanetary trajectories	CO4	T1: 4.1
25	Launch of interplanetary spacecraft	CO5	T1: 4.2 R2:4.4
26	Trajectory about the target planet.	CO6	T1: 4.3 R3:3.6
27	The boost phase	CO5	T2: 5.2
28	the ballistic phase	CO6	T2: 5.2
29	Trajectory geometry	CO5	T2: 5.3
30	optimal flights	CO6	T1: 6.1-6.2 R3: 5.5
31	Time of flight	CO 3	T1: 6.3 R2:6.1
32	Re-entry phase	CO 5	T1: 6.4 R1:5.5
33	The position of the impact point	CO 5	T1: 6.5
34	Influence coefficients	CO 5	T1: 7.1
35	Equations of Motion	CO 4	T1: 7.2
36	Constant radial thrust acceleration	CO 5	T1: 7.3 R2:3.6 R3:5.2
37	Constant tangential thrust	CO 4	T1: 7.4, R2:4.1-4.4

38	Characteristics of the motion	CO 5	T1: 7.5
39	Linearization of the equations of motion	CO 6	R2:7.3
40	Performance analysis	CO 6	T1: 7.6
PROBLEM SOLVING/ CASE STUDIES			
1	Case study of differents Method of variations of orbital elements	CO4	T2:5.6
2	Review of The position of the impact point	CO 5	T1: 6.5
3	Case study of Trajectory about the target planet.	CO6	T1: 4.3 R3:3.6
4	Case study of Ballistic Missile Trajectories	CO5,CO 6	T1, T2 R1,R2
5	Case study of Low Thrust Trajectories	CO5,CO 6	T1, T2 R1,R2,R3
6	Case study of Lagrange-Jacobi identity	CO2	T2: 3.3
7	Review of The circular restricted three body problem, Liberation points	CO 2	T2:3.4, R1: 4.1
8	Case study of Relative Motion in the N-body problem	CO2	T2 2-4
9	Review of Equations of motion-General characteristics of motion for different orbits	CO 3	T2: 3.5
10	Review of Relations between position and time for different orbits	CO 4	T2: 3.5
11	Review of Expansions in elliptic motion	CO 3	T2: 3.3
12	Case study of Orbital Elements. Relation between orbital elements and position and velocity	CO 4	T2: 3.3
13	Review of Launch vehicle ascent trajectories	CO 4	T2: 4.2
14	Case study of General aspects of satellite injection	CO 5	T2:4.3-4
15	Review of Dependence of orbital parameters on in-plane injection parameters	CO 3	T2: 5.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Module I - Introduction to Space Mechanics	CO 1	R4:2.1
2	Module II - Two Body Problem	CO 2,3	T4:7.3
3	Module III - Perturbed Satellite Orbit	CO 4	R4:5.1
4	Module IV - Ballistic Missile Trajectories	CO 5	T1:7.5
5	Module V - Low Thrust Trajectories	CO 6	T1: 4.1
DISCUSSION OF QUESTION BANK			
1	Module I - Introduction to Space Mechanics	CO 1	R4:2.1
2	Module II - Two Body Problem	CO 2,3	T4:7.3
3	Module III - Perturbed Satellite Orbit	CO 4	R4:5.1
4	Module IV - Ballistic Missile Trajectories	CO 5	T1:7.5
5	Module V - Low Thrust Trajectories	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,AE**
Dr. PK. Mohanta, Professor

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

COURSE DESCRIPTION

Department	**Aeronautical Engineering**					
Course Title	**Aerospace Structural Dynamics**					
Course Code	AAE015					
Program	B.Tech					
Semester	VII					
Course Type	Core					
Regulation	R-16					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	3	1	4	-	-	
Course Coordinator	Dr. Aravind Rajan Ayagara, Associate Professor					

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS007	I	Applied Physics
B.Tech	AME002	II	Engineering Mechanics
B.Tech	AAE002	III	Theory of Structures

II COURSE OVERVIEW:

The course aim is to teach basic concepts and recent developments related to mechanical vibrations, structural dynamics and vibration control. The course seeks to introduce students to the fundamentals of dynamics by providing an overview on mechanical vibration. Vibrations in machines and structures are typically undesirable as they produce stresses, energy losses and increased bearing loads. They contribute to structural wear and can lead to passenger discomfort in vehicles. This course covers the vibrations of discrete systems and continuous structures and introduces the computational dynamics of linear engineering systems. Learn how to derive equations of motion and design vibration isolation systems. Gain an understanding of the concepts of natural frequencies and mode shapes and their significance. Complete system modeling tasks and formulate equations to measure and ultimately minimize vibrations. The concepts of aero elasticity phenomena, effect of aero elasticity in flight vehicle design.

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
✓	Open Ended Experiments	✓	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two 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
%	Remember
33.3 %	Understand
50.0 %	Apply
16.6 %	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:

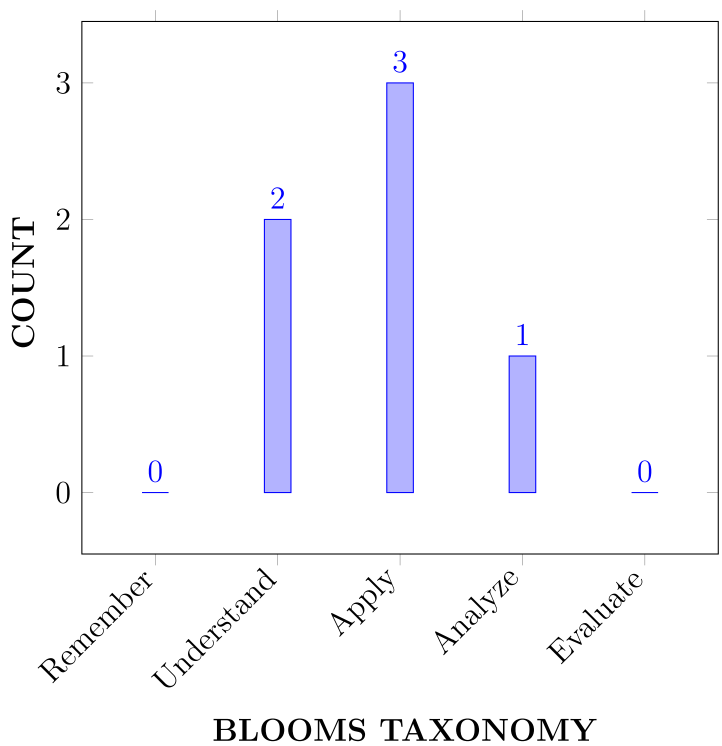
I	Demonstrate the knowledge of mathematics, science, and engineering by developing the equations of motion for vibratory systems and solving for the free and forced response.
II	Understand to identify, formulate and solve engineering problems. This will be accomplished by having students model, analyze and modify a vibratory structure order to achieve specified requirements.
III	Introduce to structural vibrations which may affect safety and reliability of engineering systems.
IV	Describe structural dynamic and steady and unsteady aerodynamics aspects of airframe and its components of space structures.

VII COURSE OUTCOMES:

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

CO 1	**Explain** the concepts of the equation of motion of free vibration and its response for determining the nature of single degree of freedom.	Understand
CO 2	**Apply** the various equations of free and forced vibration for determining the frequency of the spring-mass system.	Apply
CO 3	**Understand** the torsional vibrations of rotor and geared systems for determining the DOF of the vibrating systems.	Understand
CO 4	**Develop** the formulation of stiffness and flexibility influence coefficients for simplifying solution of multi DOF systems.	Apply
CO 5	**Apply** the transverse, longitudinal, torsional and lateral vibrations of cables, rods and beams for the design of continue elastic body.	Apply
CO 6	**Analyze** the static and dynamic aeroelasticity of the typical airfoil and wing sections of aircraft using Eigen functions and Laplace equation for design of aircraft wing.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	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	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	Use the equation of free vibrating system for the solving of the harmonic response using **mathematics, science and 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 1	Apply the equation of forced vibration system for the solving of the damped and undamped system using **mathematics and engineering fundamentals.**	1
	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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	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 **mathematics, science and 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
	PSO 1	Apply the equation of free vibrating system for the solving of the damped and damped system using **mathematics, science and Engineering fundamentals.**	2
	PSO 2	Use the equation to understand the concept of stiffness and flexibility equation by 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 1	Analyse the frequency of cable, shafts, beam for developing the new solutions on vibrating body using appropriate **mathematics, science and engineering fundamentals.**	2
	PSO 2	Simplify the equation of transverse, longitudinal, torsional and lateral vibrations for the solving of the damped and damped system using **mathematics, science and engineering fundamentals.**	1
CO 6	PO 1	Understand the concepts of static and dynamic aeroelasticity for determining flutterness of the wing structure using the knowledge of **mathematics, science and Engineering fundamentals.**	3
	PO 2	Apply the given **problem statement and formulate** the equation of static and dynamic aeroelasticity for the solving of the vibrating system using **mathematics, science and engineering fundamentals.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 3	Analyse the equation of static and dynamic aeroelasticity for the solving of the damped and damped system using **mathematics and engineering fundamentals.**	1
	PSO 1	Analyse the various vibrations generated on aircraft for developing the new solutions using appropriate **mathematics, science and engineering fundamentals.**	1
	PSO 2	Simplify the equation of Rayleigh-Ritz method for the solving of the vibration on aircraft systems using **mathematics, science and engineering fundamentals.**	1

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	3	2	-	-	-	-	-	-	-	-	-	-	1	1	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	2	1	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	2	1	-
CO 6	3	3	1	-	-	-	-	-	-	-	-	-	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	100	66.6	-	-	-	-	-	-	-	-	-	-	-	50	-
CO 2	100	66.6	-	-	-	-	-	-	-	-	-	-	33.3	50	-
CO 3	100	66.6	-	-	-	-	-	-	-	-	-	-	-	50	-
CO 4	100	66.6	-	-	-	-	-	-	-	-	-	-	66.6	50	-
CO 5	100	66.6	-	-	-	-	-	-	-	-	-	-	66.6	50	-
CO 6	100	100	33.3	-	-	-	-	-	-	-	-	-	33.3	50	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	PO 1,PO 2	SEE Exams	PO 1,PO 2, PO 4	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	PO 9, PO 10	5 Minutes Video	PO 9, PO 10	Open Ended Experiments	-
Assignments	PO 1, PO 2, PO 3				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

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	**MULTI-DEGREE-OF-FREEDOM LINEAR SYSTEMS**
	Equations of motion, free vibration, the Eigen value problem, response to an external applied load, damping effect; Modeling of continuous systems as multi-degree-of-freedom systems, using Newtons second law to derive equations of motion, influence coefficients - stiffness influence coefficients, flexibility influence coefficients, inertia influence coefficients; potential and kinetic energy expressions in matrix form, generalized coordinates and generalized forces, Lagrange's equations to derive equations of motion, equations of motion of undamped systems in matrix form, eigenvalue problem, solution of the Eigen value problem, expansion theorem, unrestrained systems, free vibration of undamped systems; forced vibration of undamped systems using modal analysis, forced vibration of viscously damped systems.
MODULE III	**NONLINEAR AND RANDOM VIBRATIONS**

	Introduction to nonlinear vibrations, simple examples of nonlinear systems, physical properties of nonlinear systems, solutions of the equation of motion of a single-degree-of-freedom nonlinear system, multi-degree-of-freedom nonlinear systems. Introduction to random vibrations; classification of random processes, probability distribution and density functions, description of the mean values in terms of the probability density function, properties of the autocorrelation function, power spectral density function, properties of the power spectral density function, white noise and narrow and large bandwidth, single-degree-of-freedom response, response to a white noise.
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**
	Collar's aeroelastic triangle, static aeroelasticity phenomena, dynamic aeroelasticity phenomena, aeroelastic problems at transonic speeds, aeroelastic tailoring, active flutter suppression. Effect of aeroelasticity in flight vehicle design.

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. Thomson, W.T., ―Theory of vibrations with applications‖, CBS Publishers, , Delhi, 3rd Edition, 2002.

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.

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2. http://arc-test.aiaa.org/doi/abs/10.2514/5.9781600862373.0719.0728
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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)			
1	Introduction to theory of vibration	CO 1	T2 : 1.2-1.13
2	Equation of motion, free vibration	CO 1	T1 : 2.1-2.2
3	Response to harmonic excitation	CO 1	T1 : 2.3-2.4, T2:1.10.1
4	Response to response to an impulsive excitation	CO 1	T1 : 2.3-2.4, T2:1.10.1
5	Relation to harmonic excitation, response to an impulsive excitation	CO 1	T1 : 2.3-2.4, T2:1.10.1
6	Response to a step excitation	CO 1	T1:1.11.1; T1:2.5-2.6
7	Response to a periodic excitation (Fourier series)	CO 1	T1:1.11.1; T1:2.5-2.6
8	Response to a periodic excitation (Fourier transform)	CO1	T1 : 2.7-2.8
9	Response to a Laplace transform (Transfer Function).	CO 1	T1 : 2.7-2.8
10	Equations of motion, free vibration.	CO 2	T1:3.1-3.3
11	The Eigenvalue problem to an external applied load.	CO 2	T1:3.1-3.3
12	Response to an external applied load.	CO 2	T1:3.1-3.3
13	Damping effect, Modeling of continuous systems as multi degree of freedom systems.	CO 2	T1:3.5; T2:6.2
14	Damping effect, using Newton's second law to derive equations of motion.	CO 2	T1:3.4; T2:6.3
15	Influence coefficients - stiffness influence coefficients.	CO 3	T2: 6.4
16	Influence coefficients - flexibility influence coefficients.	CO 3	T2: 6.4
17	Influence coefficients - inertia influence coefficients.	CO 3	T2: 6.4
18	Potential and kinetic energy expressions in matrix form.	CO 3	T2:6.5-6.6

19	Generalized coordinates and generalized forces.	CO 3	T2:6.5-6.6
20	Lagrange‘s equations to derive equations of motion.	CO 3	T2:6.7-6.9
21	Equations of motion of undamped systems in matrix form, eigenvalue problem.	CO 3	T2:6.7-6.9
22	Solution of the Eigenvalue problem of free vibration of undamped systems.	CO 3	T2:6.10-6.13
23	Solution of the expansion theorem of free vibration of undamped systems.	CO 3	T2:6.10-6.13
24	Solution of the unrestrained systems of free vibration of undamped systems.	CO 3	T2:6.10-6.13
25	Forced vibration of undamped systems using modal analysis	CO 3	T2:6.14-6.15
26	Forced vibration of viscously damped systems.	CO 3	T2:6.14-6.15
27	Introduction to nonlinear vibrations.	CO 4	T1:5.1-5.3 T3:3.3
28	Simple examples of nonlinear systems, physical properties of nonlinear systems.	CO 4	T1:5.1-5.3 T3:3.3
29	Solutions of the equation of motion of a single-degree-of-freedom nonlinear system, multi-degree-of-freedom nonlinear systems.	CO 4	T1:5.4-5.5
30	Introduction to random vibrations; classification of random processes, probability distribution and density functions, description of the mean values in terms of the probability density function.	CO 4	T1:6.1-6.4R3:4.4
31	Properties of the autocorrelation function, power spectral density function, properties of the power spectral density function, white noise and narrow and large bandwidth, single-degree-of-freedom response, response to a white noise.	CO 4	T1:6.5-6.10 R3:5.4, T3:4.3
32	Introduction, transverse vibration of a string or cable.	CO 5	T2:8.1-8.2
33	longitudinal vibration of a bar or rod.	CO 5	T2:8.3
34	torsional vibration of a bar or rod.	CO 5	T2:8.4 R2:5.3
35	Lateral vibration of beams, the Rayleigh-Ritz method.	CO 5	T2:8.5-8.7
36	Collar's aero elastic triangle, static aeroelasticity phenomena.	CO 6	T1:5.1, R1:1.2
37	Dynamic aero elasticity phenomena, aero elastic problems at transonic speeds.	CO 6	T1:5.3, R1:2.2
38	Aero elastic tailoring.	CO 6	T1:7.1, R2:1.3
39	Active flutter suppression.	CO 6	T1:7.1-7.3 R2:1.3

40	Effect of aero elasticity in flight vehicle design.	CO 6	T1:7.3, R1:3.4
PROBLEM SOLVING/ CASE STUDIES			
1	Problems on response to harmonic excitation	CO 1	
2	Problems on response to an impulsive excitation	CO 1	
3	Problems on response to a periodic excitation (Fourier transform), Laplace transform (Transfer Function)	CO 1	
4	Problems on Influence coefficients and stiffness influence coefficients, flexibility influence coefficients, inertia influence coefficients	CO 2	
5	Problems on flexibility influence coefficients, inertia influence coefficients	CO 2	
6	Problems on lagrange‘s equations to derive equations of motion, undamped systems in matrix form and eigenvalue	CO 2	
7	Problems on solutions of the equation of motion of a multi-degree-of-freedom nonlinear systems	CO 3	
8	Problems on probability distribution and density functions	CO 3	
9	Problems on transverse, longitudinal and torsional vibrations of a string or cable, bar or rod	CO 4	
10	Problems on lateral vibration of beams	CO 4	
11	Problems on Rayleigh-Ritz method on multi degree of freedom	CO 5	
12	Problems on single-degree-of-freedom response on nonlinear	CO 5	
13	Problems on Dynamic aero elasticity at transonic speeds	CO 6	
14	Problems on aero elastic active flutter suppression	CO 6	
15	Problems on aero elastic tailoring on vibrating system	CO 6	
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Response to a periodic excitation (Fourier transform), Laplace transform (Transfer Function).	CO 1	T1 : 2.7-2.8
2	Damping effect; Modeling of continuous systems as multi degree of freedom systems, using Newton’s second law to derive equations of motion.	CO 2	T1:3.4; T2:6.2-6.3
3	Influence coefficients - stiffness influence coefficients, flexibility influence coefficients, inertia influence coefficients.	CO 3	T2: 6.4
4	Properties of the autocorrelation function, power spectral density function, properties of the power spectral density function, white noise and narrow and large bandwidth, single-degree-of-freedom response, response to a white noise	CO 5	T1:6.5-6.10, R3:5.4, T3:4.3
5	Dynamic aero elasticity phenomena, aero elastic problems at transonic speeds	CO 6	R1:2.2
DISCUSSION OF QUESTION BANK			
1	Module I	CO 1	T2 : 1.2-1.13
2	Module II	CO 2	T1:3.4; T2:6.3
3	Module III	CO 3	T1:3.4; T2:6.3

4	Module IV	CO 4, CO 5	T1:5.4-5.5
5	Module V	CO 6	T1:7.3, R1:3.4

Signature of Course Coordinator **HOD,AE**
Dr. Aravind Rajan Ayagara, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION

<table>
<tr><td>Course Title</td><td colspan="5">COMPUTATIONAL STRUCTURAL ANALYSIS LABORATORY</td></tr>
<tr><td>Course Code</td><td colspan="5">AAE111</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td>VII</td><td colspan="4">AE</td></tr>
<tr><td>Course Type</td><td colspan="5">Core</td></tr>
<tr><td>Regulation</td><td>IARE - R16</td><td colspan="4"></td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>3</td><td>2</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Mr. Gooty Rohan, Assistant Professor</td></tr>
</table>

I COURSE OVERVIEW:

Computational Structural Analysis Laboratory sessions focus on the creation of geometry, meshing (Discretization) and the physics behind the stress strain variation on a continuum. It will also cover the different solvers available in a FEA package and their applications based on the problem type. This course offers a wide range of applications in aircraft structural analysis such as deflection of truss, frames, beams, stress and strain distributions in a plate as well as a solid continuum. Apart from these, it will also address the nonlinear stress problems alongside vibration and flutter analysis.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAE002	III	Theory of Structures
B.Tech	AAE006	IV	Analysis of Aircraft Structures
B.Tech	AAE009	V	Finite Element methods

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
CSA LAB	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner,

both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

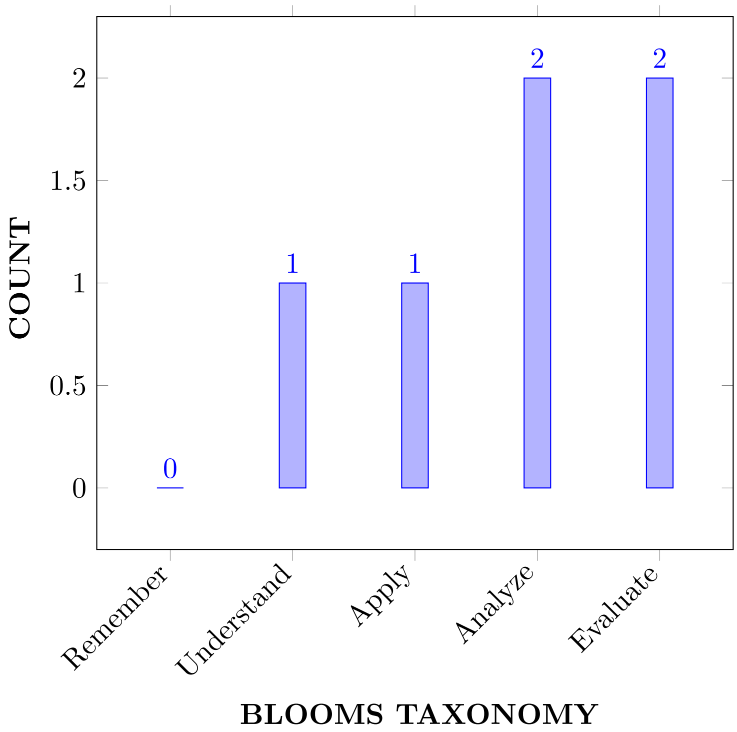
I	Make the student familiar with latest computational techniques and software used for structural analysis.
II	. Enable the student to get a feeling of how real-life structures behavior for static and dynamics loads.
III	. Become familiar with professional and contemporary issues in the design and fabrication.

VII COURSE OUTCOMES:

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

CO 1	**Explain** the computational methods and Softwares that are used in aerospace fields to simulate the complex problems through ANSYS.	Understand
CO 2	**Solve** the parameters like deflections, stress, strain and bending moment by using ANSYS for the linear and non-linear problems that occur in aircraft structural components (beams, bars etc.).	Apply
CO 3	**Calculate** the numerical solution of static structural problems using discretization methods and convergence criteria to minimize the errors.	Analyze
CO 4	**Select** the appropriate heat transfer mechanism using ANSYS thermal workbench for efficient cooling of on board avionics system.	Analyze
CO 5	**Predict** the suitable appropriate results using governing equations for vibrational problems that occur in aircraft structural components (beams, spring-mass system)	Evaluate
CO 6	**Determine** the nature of stress-strain distribution by using appropriate governing equations for an aircraft structural components such as wings, fuselage and landing gear.	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

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

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

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the basic conservation laws of science for various phenomena of fluid systems and use **mathematical principles** for deriving (complex) fluid flow engineering equations by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals** of fluid mechanics	3
	PO 2	Identify the physical problems with different surfaces and geometries(2D and 3D) for which the temperature distribution and velocity propagation are calculated from numerical methods using principles of **engineering mathematics and sciences.**	2
	PO 3	**Design/development a appropriate solutions** for complex engineering problems using the numerical methods (ANSYS)	3
	PO 4	Make a use of **research methodologies** to investigate the experimental, analytical data with numerical simulational results with ANSYS workbench	1
	PO 5	Identify the suitable **modern software** in order create, select and the apply for complex engineering problems to obtain results.	3
	PO 9	Understand the complex problems either by **individual or team work** to obtain the appropriate results.	3
	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments.	2
	PO 12	Apply the skills learnt in the lab to solve **real life problems** using ANSYS Workbench	3
	PSO 3	Outline the finite element methods adopted in **computational techniques** for **simulation** of fluid thermal systems for **innovative career** path in industry for **modern tool** usage.	3
CO 2	PO 1	Develop the computational programs for governing equations of structural analysis problems from the **mathematical principles** and **engineering fluid thermal sciences**.	3
	PO 2	Identify the principles associated with Static structural problems to **formulate** and calculate the deflection variables **using principles of mathematics, Design and engineering sciences**.	2
	PO 3	**Design/development a appropriate solutions** for complex static structural problems using the ANSYS workbench	3

	PO 4	Make a use of **research methodologies** to investigate the structural problems of the experimental, analytical data with numerical simulational results	3
	PO 5	Identify the suitable **modern software** in order create, select and the apply for linear and non-linear problems to obtain the results.	3
	PO 9	Understand the linear and non-linear structural problems either by **individual or team work** to obtain the approximate results.	3
	PO 10	Make use of **communication skill to write lab related documents** for effective communication with diverse engineering segments.	2
	PO 12	Apply the skills learnt in the ANSYS lab to identify the solutions for **real life problems** using suitable Workbench	3
	PSO 3	Outline the finite element methods adopted in **computational techniques** for **simulation** of structural systems for **innovative career** path in industry for **modern tool** usage.	3
CO 3	PO 1	Develop the computational programs for governing equations of structural analysis problems from the **mathematical principles** and **engineering fluid thermal sciences**.	3
	PO 2	Understand the given **problem statement and formulate** complex engineering problems by modeling ,meshing and applying corresponding boundary **information and data** in reaching substantiated conclusions by the **interpretation of results**.	2
	PO 3	**Design/development a appropriate solutions** for complex static structural problems using the ANSYS workbench	2
	PO 4	Make a use of **research methodologies** to investigate the static structural problems of the experimental, analytical data with numerical simulational results	3
	PO 5	Using the suitable **modern software (ANSYS)** in order to identify the solutions for static structural problems using appropriate mesh methods.	3
	PO 9	Understand the approximate results either by **individual or team work** for complex engineering problems through ANSYS.	3
	PO 10	Utilize the **communication skills to write lab related documents** for an effective communication with diverse engineering segments.	2
	PO 12	Apply the skills learnt in the ANSYS lab to identify the solutions for **real life problems** using suitable Workbench	3
	PSO 3	Outline the finite element methods adopted in **computational techniques** for simulation of static-structural systems to **innovative career** path in industry for **modern tool** usage.	2

CO 4	PO 1	Develop the computational programs for governing equations of structural analysis problems from the **mathematical principles** and **engineering fluid thermal sciences**.	3
	PO 2	**Identify** and Understand the given heat transfer problem and **formulate** the appropriate heat flow technique by using **first principles of mathematics** (Partial differential equations).	2
	PO 3	Identify the various techniques that are used to **Design/ develope a numerical solution** for an complex heat transfer problems with ANSYS.	3
	PO 4	Make a use of **research methods** to investigate the complex heat transfer problems to validate the numerical results with experimental data.	3
	PO 5	Using techniques that are in modern tools (ANSYS) to **create, select and apply** the solutions for various heat transfer problems	3
	PO 9	Understand the complex heat transfer problems either by **individual or team work** to identify the solutions through ANSYS.	3
	PO 10	Utilize the **communication skills to write lab related documents** for an effective communication with diverse engineering segments.	2
	PO 12	Apply the skills learnt in the ANSYS lab to identify the solutions for **real life problems** using suitable Workbench	2
	PSO 3	Outline the numerical methods adopted in **computational techniques** for simulation of heat flow systems to **innovative career** path in industry for **modern tool** usage.	3
CO 5	PO 1	Develop the computational programs for governing equations of vibrational analysis problems from the **mathematical principles** and **engineering sciences**.	3
	PO 2	**Identify and formulate** an expression for complex vibrational problems using governing equations with ANSYS.	2
	PO 3	**Design and develop** a solution for vibrational problems that meet the specified needs with appropriate consideration.	2
	PO 4	Make a use of engineering knowledge to **conduct an investigations of complex** vibrational problems using ANSYS.	3
	PO 5	Utilize the **Modern tools (ANSYS)** to create, select and apply the techniques for identifying the solution for complex problems.	3
	PO 9	Resolve the vibrational problems using appropriate techniques and identify the effective solutions either by **individually or team work**.	3
	PO 10	By using the **communication and report writing skills** to develop the effective lab document.	2

	PO 12	Apply the skills learnt in the ANSYS lab to identify the solutions for **real life problems** using suitable Workbench	3
	PSO 3	Make a use of **multi physics and computational methods** for bulding the career paths towards employability and higher studies.	2
CO 6	PO 1	Analyze the different discretization methods for identifying the stress-straindistribution by using **mathematics, science andengineering fundamentals** to minimize the errors.	3
	PO 2	**Identify and formulate** an expression for complex aircraft structural problems using governing equations with ANSYS.	2
	PO 3	**Design and develop** a solution for various stress-strain distribution that are occured in the aircraft structure to meet the specified needs with appropriate consideration.	2
	PO 4	**Knowledge and understanding** the basic processes to **conduct investigations of complex problems** in the design of aircraft structural components to **provide numerical solution** in order to minimize the error.	3
	PO 5	Make use of **modern tools (ANSYS)** to create, select and apply the techniques for identifying the stress-strain values of aircraft components.	3
	PO 9	Resolve the aircraft wing, fuselage, and landing gear stress-strain distribution values using appropriate techniques and identify the effective solutions either by **individually or team work**.	3
	PO 10	By using the **communication and report writing skills** to generate an effective engineering report.	2
	PO 12	Apply the skills learnt in the ANSYS lab to identify the solutions for **real life problems** using suitable Workbench	3
	PSO 3	Make a use of **multi physics and computational methods** for bulding the career paths towards employability and higher studies.	3

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

Course	Program Outcomes								PSO'S
Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 9	PO10	PO12	PSO 3
CO 1	3	2	3	1	3	3	2	3	3
CO 2	3	2	3	3	3	3	2	3	3
CO 3	3	2	2	3	3	3	2	3	2
CO 4	3	2	3	3	3	3	2	2	3
CO 5	3	2	2	3	3	3	2	3	2
CO 6	3	2	2	3	3	3	2	3	3

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**INTRODUCTION AND BASIC FUNCTIONS**
	Starting up of ANSYS/NASTRAN. Description of user interface.
WEEK II	**STATIC ANALYSIS: TRUSSES AND FRAMES STRUCTURES**
	2D truss structures 3D truss structures
WEEK III	**STATIC ANALYSIS: BEAMS**
	Straight Beams Tapered Beams
WEEK IV	**STATIC ANALYSIS: TWO DIMENSIONAL PROBLEMS**
	2D Structure with various loadings 2D Structure with various materials Plate with a hole
WEEK V	**DYNAMIC ANALYSIS: MODAL AND TRANSIENT ANALYSIS**
	Modal analysis. Transient Response of spring mass system.
WEEK VI	**THERMAL ANALYSIS**
	Bars and Beams. 2D Structures.
WEEK VII	**NONLINEAR ANALYSIS**
	Non-linear behavior (large deflections) Non-linear behavior (materials)
WEEK VIII	**HARMONIC RESPONSE ANALYSIS**
	Random Vibration Analysis of a deep simply-supported beam. Harmonic response of a spring-mass system
WEEK IX	**ANALYSIS OF AIRCRAFT STRUCTURE : WING**
	Static analysis of aircraft wing structure. Modal analysis of aircraft wing structure.
WEEK X	**ANALYSIS OF AIRCRAFT STRUCTURE: FUSELAGE**

	Static analysis of aircraft semi monoque fuselage structure. Modal analysis of aircraft semi monoque fuselage structure.
WEEK XI	**ANALYSIS OF AIRCRAFT STRUCTURE: LANDING GEAR**
	Static analysis of aircraft landing gear. Modal analysis of aircraft landing gear.
WEEK XII	**ANALYSIS OF COMPOSITE STRUCTURES**
	Static analysis of composite bar and beam. Modal analysis of composite plate.

TEXTBOOKS

1. Huei-Huang Lee, —Finite Element Simulations with ANSYS Workbench 16‖, SDC publications, 2 nd Edition, 2016.

2. Anderson, William J —MSC/Nastran: Interactive Training Program‖ Wiley 1 st Edition 2015

REFERENCE BOOKS:

1. Huei-Huang Lee, —Finite Element Simulations with ANSYS Workbench 16‖, SDC publications, 2nd Edition, 2016.

2. Anderson, William J —MSC/Nastran: Interactive Training Program‖ Wiley 1 st Edition 2015.

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Introduction to simulation software.	CO 1	R1: 1.2
2	Introduction to ANSYS.	CO 1	R2: 3.5
3	Verification of Bernoulli's theorem.	CO 1	R1: 3.4
4	Determination of 2-D, 3-D truss structures.	CO 2	R1: 2.2
5	Determine the static-structural analysis.	CO 2	R1: 2.4
6	Determine the Structural analysis of beams under different load condition.	CO 3	R2: 4.5
7	Determine the model analysis of beams and spring-mass system.	CO 3	R2: 4.6
8	Determine the non-linear analysis for large deflections.	CO 4	R2: 5.1
9	Determine the harmonic response analysis of simply-supported beam.	CO 5	R2: 5.2
10	Determine the harmonic response analysis of a spring-mass system	CO 5	R1: 7.1
11	Determine the structural analysis of aircraft wings, fuselage, and landing gear	CO 6	R1:7.2
12	Determine the analysis of composite structures	CO 6	R1:7.3

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Uni-axial tensile** tests of different aircraft grade metals.
2	**Uni-axial compression** tests of different aircraft grade metals.
3	**Three-point bending** tests of a simply supported beam.
4	**Bending** of a cantilever beam.
5	**Harmonic vibration** of a beam

Signature of Course Coordinator **HOD,AE**
Mr. Gooty Rohan, Assistant Professor

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

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**AUTOMATIC CONTROL OF AIRCRAFT**				
Course Code	AAE532				
Program	B.Tech				
Semester	VIII	AE			
Course Type	PE				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr.Yagya Dutta Dwivedi, Professor				

I COURSE OVERVIEW:

This course is intended to study the automatic control of the flight vehicles through the air or in outer space. It concerns the forces and moments, that are acting on the air- vehicles to determine the position and attitude with respect to the time. It also develops as an engineering science throughout succeeding generations of aeronautical engineers to support increasing demands of autonomous aircraft navigation and control. It has a major role to play in the design of modern aircraft to ensure efficient, comfortable and safe flight. Modern aircraft control is ensured through automatic control systems known as autopilot in association with Fly-by- Wire, to increase safety, facilitate the pilot's task easier and improve flight qualities.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB09	IV	Flight Mechanics
B.Tech	AAEB13	V	Aircraft stability and control

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Automatic control of aircraft	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
25 %	Understand
60 %	Apply
15 %	Analyze

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

Quiz - Online Examination

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

Alternative Assessment Tool (AAT)

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

Concept Video	Tech-talk	Open Ended Experiment
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

I	The fundamental theory of guidance and control systems of aircraft and also different augmentation systems used for aircraft and space vehicles.

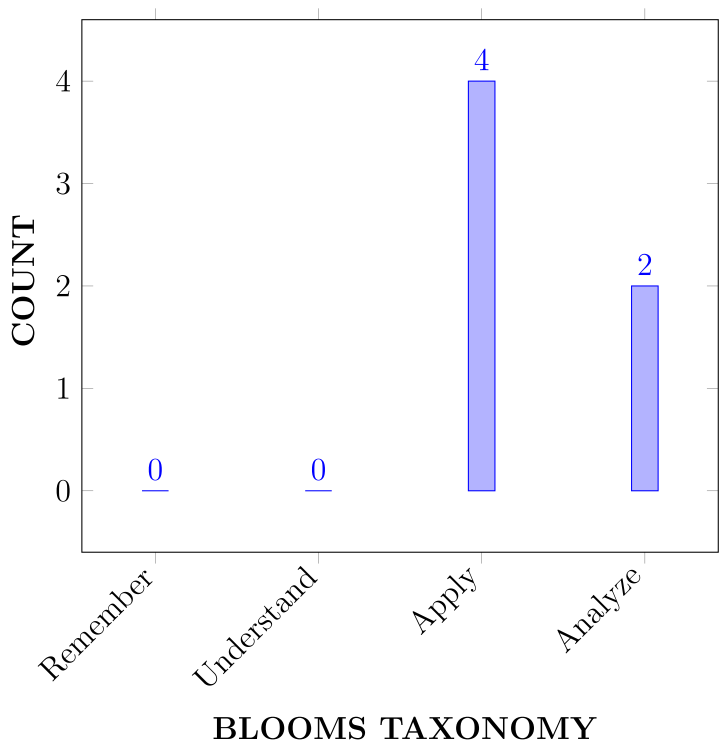
II	Various components and propellants of a chemical rocket propulsion system with its characteristics and applications.Different autopilot systems, flight path stabilization and Automatic Flare Control systems used for flight vehicles.
III	The operating principle of guided missile, and the guidance, control and instrumentation needed to acquire theThe modern automatic control systems like Fly-by-Wire, Fly-by-Optics systems and different flight control laws design using different algorithms.
IV	Advanced computational tools to design of navigation and guidance systems for automation of aircrafts, missiles, helicopters and space launch vehicles.

VII COURSE OUTCOMES:

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

CO 1	**Identify** the principles of guidance, navigation, and governing laws for the control of aircraft for getting the desired aircraft attitude.	Apply
CO 2	**Demonstrate** the automatic flight control system under different types of flight conditions for assessing the stability and control of an airplane	Apply
CO 3	**Examine** the automatic gain schedule concept for airplane control by plotting the required curve f or obtaining desired automatic control of the flight vehicle.	Analyze
CO 4	**Apply** the concept of displacement autopilots and orientation control in longitudinal motion with its elements f or optimal flight automated control of the airplane.	Apply
CO 5	**Make use of** the aircraft longitudinal flight control laws by using simple stepping algorithm for optimizing the required control of the flight vehicles.	Apply
CO 6	**Analyze** the fly-by-wire flight control by using flight control laws and modern computational tools system for the assessment of redundancy and failure of the aircraft operation.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	2	Research papers / Group discussion / Short term courses
PSO 3	Make use of design, computational and experimental tools for research and innovation in aerospace technologies and allied streams, to become successful professional, entrepreneurs and desire higher studies.	2	Research papers / Industry exposure

3 = High; 2 = Medium; 1 = Low

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

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

CO 6	✓	✓	-	-	-	-	-	-	-	-	-		-	-	✓

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	**Apply)** the basic concept of guidance and control to understand the historical progression by using the **Scientific and mathematical principles in Aeronautical discipline.**	3
CO 2	PO 1	**Describe (knowledge)** the need for automatic flight control using **principles of mathematics, science, and engineering fundamentals**.	3
	PO 2	**Recognize problems** related to design of civil and military navigation and control of aircraft motion by **conclusions using first principles of mathematics natural sciences, and Engineering sciences to validate experimental results by available data.**	5
CO 3	PO 1	**Describe (knowledge)** the state of displacement autopilots and pitch orientations using **principles of mathematics, science, and engineering fundamentals**.	3
	PO 2	**Recognize problems** related to design of civil and military aircraft displacement autopilots by assessing **conclusions using first principles of mathematics natural sciences, and Engineering sciences to validate experimental results by available data.**	5
	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 flight path stabilization and control with the use of **fundamentals of mathematics,and engineering fundamentals** in aircraft automatic control.	2
	PO 2	**Recognize problems** related to design of civil and military navigation and control of aircraft motion by **conclusions using first principles of mathematics natural sciences, and Engineering sciences to validate experimental results by available data.**	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 5	PO 1	**Interpret** the specific coupling between Damping and dutch roll with the **knowledge of mathematics, 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, and desire higher studies**.	2
CO 6	PO 1	**Interpret** the specific coupling between Damping and dutch roll with the **knowledge of mathematics, and engineering fundamentals related to aeronautics.**	2
	PO 2	**Recognize problems** related to design of civil and military fly by wire system by **conclusions using first principles of mathematics natural sciences, and Engineering sciences to validate experimental results by available data.**	5
	PSO 3	**Understand** the characteristics of aircraft longitudinal / lateral control by using **modern tool** to go further one level to become entrepreneur.	1

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

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

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

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

CO 3	100	60	-	50	-	-	-	-	-	-	-	-	-	-	-
CO 4	67	70	-	-	-	-	-	-	-	-	-		-	67	-
CO 5	67	-	-	50	-	-	-	-	-	-	-	-	-	67	-
CO 6	100	50	-	-	-	-	-	-	-	-	-		-	-	34

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	3	-	-	-	-	-	-	-	-	-		-	3	-
CO 5	3	-	-	2	-	-	-	-	-	-	-	-	-	3	-
CO 6	3	2	-	-	-	-	-	-	-	-	-		-	-	1
TOTAL	18	9	-	4	-	-	-	-	-	-	-	-	-	6	1
AVERAGE	3	2.2	-	2	-	-	-	-	-	-	-	-	-	3	1

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term paper	-	Concept Video	✓	Open Ended Experiments	✓
Assignments	-	Techtalk	✓		

XVI ASSESSMENT METHODOLOGY INDIRECT:

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

XVII SYLLABUS:

MODULE I	**INTRODUCTION**
	Introduction to Guidance and control: Definition, historical background.
MODULE II	**AUGMENTATION SYSTEMS**
	Need for automatic flight control systems, stability augmentation systems, control augmentation systems, gain scheduling concepts.
MODULE III	**LONGITUDINAL AUTOPILOT**
	Displacement Autopilot: Pitch orientation control system, acceleration control system, glide slope coupler and automatic flare control. Flight path stabilization, longitudinal control law design using back stepping algorithm.
MODULE IV	**LATERAL AUTOPILOT**
	Damping of the Dutch roll, methods of obtaining coordination, yaw orientation control system, turn compensation, automatic lateral beam guidance.
MODULE V	**FLY BY WIRE FLIGHT CONTROL**
	Introduction to Fly-by-wire flight control systems, fly-by-wire flight control features and advantages, control laws, redundancy and failure survival, digital implementation, fly-by-light flight control.

TEXTBOOKS

1. Blake Lock, J.H, —Automatic control of Aircraft and missiles, John Wiley Sons, New York, 1990.
2. Stevens B.L and Lewis F.L, —Aircraft control and simulation, John Wiley Sons, New York, 1992
3. Collinson R.P.G, —Introduction to Avionics, Chapman and Hall, 1st Edition India, 1996.

REFERENCE BOOKS:

1. Garnel.P. and East. D.J, —Guided Weapon control systems, Pergamon Press, Oxford, 1st Edition 1977
2. Bernad Etikin, —Dynamic of flight stability and control, John Wiley, 1st Edition 1972.
3. Nelson R.C, —Flight stability and Automatic Control, McGraw Hill, 1st Edition 1989.

XVIII COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1			
DISCUSSION OF QUESTION BANK			
2	Basic introduction to guidance and control.	CO 1	T2: 1.1-1.5, T1: 4.1
3	Definition of different types of guidance and the terms used	CO 1	T2: 2.1-2.2, R1: 3.1
4	Historical background	CO 1	T2: 2.1-2.2, R1: 3.1

5	Development of the guidance system	CO 1	R4: 2.8
6	Types of guidance system- Active verses passive homing guidance	CO 1	T2: 2.3-2.4
7-8	Command guidance system	CO 2	R1: 2.7.1
8	Need for automatic flight control systems	CO 1	R1: 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	T2: 7.1
13	Displacement Autopilot	CO 1	R1: 6.3.3
14	CL trim Vs δ_e Trim and Numerical	CO 1	R1: T6.3.2
15	Pitch orientation control system	CO 2	R1: 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	R1: 7.1
19	Directional Stability and Control	CO 2	T3: 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	R2: 2.8
4	Development of Flight augmentation system- a review	CO 2	R2: 6.3.2
5	Numerical problems related to guidance system	CO 2	R4: 6.3.2
6	CL Basic gain scheduling system and its application and modern development in this area.	CO 2	R2: 6.3.2
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	T2: 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	T3:7.3
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	Guidance and control of the airplane.	CO 1	T2: 1.1-1.5
2	Aircraft fligjt control augmentation system.	CO 2	R4: 6.3.2
3	Longitudinal Autopilot.	CO 3, 4	R3:5.1
4	Lateral Autopilot	CO 5	T3: 11.2-11.4
5	Fly by Wire in airplane	CO 6	T1:11.2-11.4, T3:14.3

Signature of Course Coordinator **HOD,AE**
Dr. Yagya Dutta Dwivedi, Professor

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

COURSE DESCRIPTION

Department	**CIVIL ENGINEERING**				
Course Title	ENERGY FROM WASTE				
Course Code	AEE551				
Program	B.Tech				
Semester	VII				
Course Type	Open Elective				
Regulation	IARE R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. Ch.Balakrishna, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS005	I	Engineering Chemistry
B.Tech	AHS009	II	Environmental Studies

II COURSE OVERVIEW:

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

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Energy From Waste	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
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
20%	Remember
60%	Understand
20%	Apply
0%	Analyze
0%	Evaluate

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	Open Ended Experiment
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

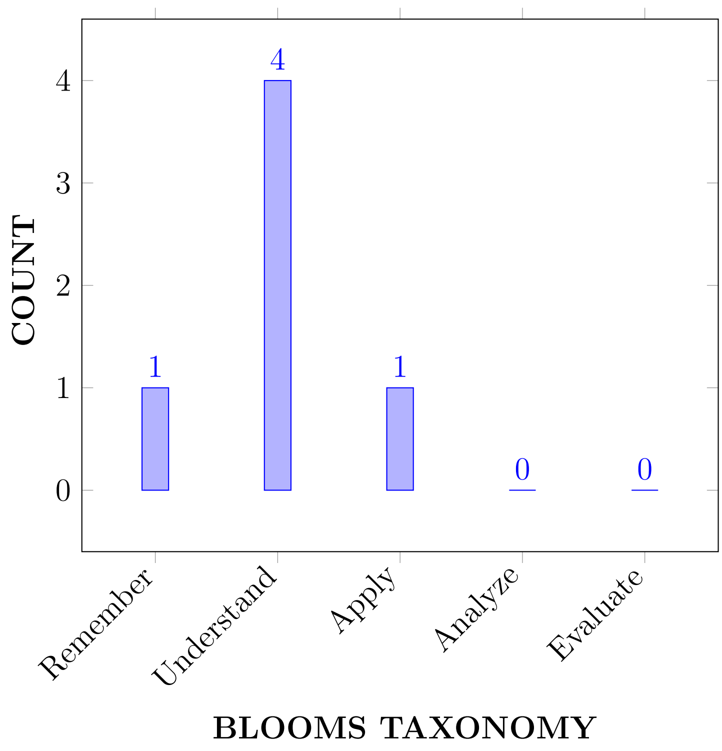
I	The principles of solid waste management in reducing and eliminating dangerous impacts of waste materials on human health and the environment to contribute economic development and superior quality of life.
II	The insight of the design and operations of a municipal solid waste landfill by collection,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

VII COURSE OUTCOMES:

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

CO 1	**Identify** the different sources, types of solid waste by the properties of municipal solid waste for segregation and collection of waste.	Remember
CO 2	**Understand** the Composition, characteristics of leachate and preliminary design considerations of landfill to control the emission of gases and monitoring the movement of landfill leachate.	Understand
CO 3	**Outline** the Biochemical conversion of biomass for energy generation by anaerobic digestion of solid waste.	Understand
CO 4	**Illustrate** the thermo-chemical conversion of solid waste by using Gasification and pyrolysisprocess for energy generation.	Understand
CO 5	**Identify** the need to stringent health safeguards and environmental protection laws of India for the effective disposal of E-waste.	Apply
CO 6	**Interpret** the global scenario of environmental concerns and health hazards by the generation of E- waste.	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.

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 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 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	CIE/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/Quiz/AAT

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 2	Focus on Improving Performance of Structures with reference to Safety, Serviceability and Sustainable Green Building Technology.	3	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 matched.**
CO 1	PO 1	Apply the **Scientific principles** for energy generation by applying different technologies from waste management plants.	1
	PO 3	Identify the **constraints including environmental health and safety and risk assessment issues** of different methods of disposal of municipal solid waste by aerobic composting **to promote sustainable development.**	2
	PO 6	Apply the **knowledge of management techniques** by understanding the **requirement for engineering activities**of municipal solid waste for the **sustainable development**.	3
	PO 7	Interpret the discarding of solid waste and their impact on **socio economic, environment** is considered and energy generation activities by aerobic composting of waste.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO 3	Identify **constraints including environmental and sustainability limitations, health and safety and risk assessment issues** for environmental monitoring system of land fill gases and composition of leachate and **Understanding commercial and economic context** of managing the land fill site	2
	PO 6	Understand the characteristics, generation and movement of leachate in landfills by the **management techniques** which uses for controlling the emission of gases in landfills **to promote sustainable development**	2
CO 3	PO 1	Explain the **Scientific principles** for Energy generation from waste bio-chemical conversion and **to integrate / support the engineering disciplines**	2
	PO 6	Apply the knowledge in planning and operations of waste to Energy plants **for sustainable development** by following **legal legislation** related to solid waste management for **high level of professional and ethical values.**	3
	PO 7	Identify the sources of energy generation by anaerobic digestion of sewage and municipal waste for **socio economic solutions** and direct combustion of municipal solid waste for environmental solutions.	2
	PSO 2	Identify the Energy generation processes from waste by bio-chemical conversion and help in **Sustainable** development and **Safety** of the public life.	2
CO 4	PO 1	Illustrate the methods of pyrolysis process by understanding **Scientific principles and methodology** and apply to **integrate / support study of their own engineering discipline** for solving environmental problems	2
	PO 3	Interpret thermo-chemical conversion sources of energy generation, gasification of waste and **identify constraints including environmental and sustainability limitations**	2
	PO 7	Understand the environmental benefits by using thermo-chemical process will decrease the emission of harmful gases and will attain **Environmental sustainability.**	1
CO 5	PO 6	Define the global scenario of environmental concerns by the increase in the generation of E-waste worldwide causing the **personnel, health, safety, and risk (including environmental risk) issues** and the problem can solved by imposing strong legal regulation for disposing of E-waste and help in **sustainable development**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 12	List out the health hazards by the generation of E-waste and their impact on environment will be solved by the proper management and formal disposal of E-waste and this can be achieved by long term learning process in **Professional certifications, advanced degree** for developing advanced technologies in recycling of E-waste.	2
	PSO 2	Apply strong environmental protection laws in India for the effective disposal of E-waste and constraints including environmental and **sustainability** development and while recycling the E-waste and problem including production, operation, maintenance and disposal with proper **safety**	2
CO 6	PO 6	Define the global scenario of environmental concerns by the increase in the generation of E-waste worldwide causing the **personnel, health, safety, and risk (including environmental risk) issues** and the problem can solved by imposing strong legal regulation for disposing of E-waste and help in **sustainable development**	2
	PO 12	List out the health hazards by the generation of E-waste and their impact on environment will be solved by the proper management and formal disposal of E-waste and this can be achieved by long term learning process in **Professional certifications, advanced degree** for developing advanced technologies in recycling of E-waste.	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	1	-	2	-	-	3	2	-	-	-	-	-	-	-	-
CO 2	-	-	2	-	-	2	-	-	-	-	-	-	-	-	-
CO 3	2	-	-	-	-	3	2	-	-	-	-	-	-	2	-
CO 4	2	-	2	-	-	-	1	-	-	-	-	-	-	-	-
CO 5	-	-	-	-	-	2	-	-	-	-	-	2	-	2	-
CO 6	-	-	-	-	-	2	-	-	-	-	-	2	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	33.3	-	20.0	-	-	60.0	66.6	-	-	-	-	-	-	-	-
CO 2	-	-	20.0	-	-	40.0	-	-	-	-	-	-	-	-	-
CO 3	66.6	-	-	-	-	60.0	66.6	-	-	-	-	-	-	66.6	-
CO 4	66.6	-	20.0	-	-	-	33.3	-	-	-	-	-	-	-	-
CO 5	-	-	-	-	-	40.0	-	-	-	-	-	25	-	66.6	-
CO 6	-	-	-	-	-	40.0	-	-	-	-	-	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	1	-	1	-	-	2	3	-	-	-	-		-	-	-
CO 2	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	2	3	-	-	-	-	-	-	3	-
CO 4	3	-	1	-	-	-	1	-	-	-	-		-	-	-
CO 5	3	-	-	-	-	1	3	-	-	-	-	1	-	3	-
CO 6	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-
TOTAL	10	-	3	-	-	7	10	-	-	-	-	2	-	6	-
AVERAGE	3.0	-	1.0	-	-	1.0	3.0	-	-	-	-	1.0	-	3.0	

XVI ASSESSMENT METHODOLOGY DIRECT:

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

XVII ASSESSMENT METHODOLOGY INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

UNIT - I	**INTRODUCTION TO WASTE AND WASTE PROCESSING**
	Solid waste sources solid waste sources, types, composition, properties, global warming; Municipal solid waste: Physical, chemical and biological properties, waste collection and, transfer stations, waste minimization and recycling of municipal waste, segregation of waste, size reduction, managing waste, status of technologies for generation of energy from waste treatment and disposal aerobic composting, incineration, furnace type and design, medical waste / pharmaceutical waste treatment technologies, incineration, environmental impacts, measures to mitigate environmental effects due to incineration
UNIT - II	**WASTE TREATMENT AND DISPOSAL**
	Land fill method of solid waste disposal land fill classification, types, methods and sitting consideration; Layout and preliminary design of landfills: Composition, characteristics, generation, movement and control of landfill leachate and gases, environmental monitoring system for land fill gases.
UNIT - III	**BIO-CHEMICAL CONVERSION**
	Energy generation from waste bio-chemical conversion: Sources of energy generation, anaerobic digestion of sewage and municipal waste, direct combustion of MSW-refuse derived solid fuel. Industrial waste, agro residues and anaerobic digestion.
UNIT - IV	**THERMO-CHEMICAL CONVERSION**
	Biogas production, land fill gas generation and utilization, thermo-chemical conversion: Sources of energy generation, gasification of waste using gasifies briquetting, utilization and advantages of briquetting, environmental benefits of bio-chemical and thermo-chemical conversion
UNIT - V	**E-WASTE MANAGEMENT**
	E-waste: E-waste in the global context: Growth of electrical and electronics industry in India, environmental concerns and health hazards; Recycling e-waste: A thriving economy of the unorganized sector, global trade in hazardous waste, impact of hazardous e-waste in India; Management of e-waste: E-waste legislation, government regulations on e-waste management, international experience, need for stringent health safeguards and environmental protection laws of India.

TEXTBOOKS

1. Nicholas P Cheremisinoff, —Handbook of Solid Waste Management and Waste Minimization Technologie, An Imprint of Elsevier, New Delhi, 2003.
2. P AarneVesilind, William A Worrell and Debra R Reinhart, —Solid Waste Engineering, 2 nd edition 2002.

3. M Dutta , B P Parida, B K Guha and T R Surkrishnan, —Industrial Solid Waste Management and Landfilling practice, Reprint Edition New Delhi, 1999.

4. RajyaSabha Secretariat, —E-waste in India: Research unit, Reprint Edition, June, 2011.

REFERENCE BOOKS:

1. C Parker and T Roberts (Ed), —Energy from Waste, An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.

2. KL Shah,"Basics of Solid and Hazardous Waste Management Technology", Prentice Hall, Reprint Edition, 2000.

3. M Datta, —"Waste Disposal in Engineered Landfill", Narosa Publishing House, 1997.

WEB REFERENCES:

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

COURSE WEB PAGE:

1. https://akanksha.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 T1: 4.1
	OBE DISCUSSION		
	Outcome Based Education, CO PO attainment and Blooms Taxonomy		
	CONTENT DELIVERY (THEORY)		
1	Sources of Municipal Solid waste	CO 1	T1:3.3, T2:1.2, R2: 2.2
2	Types of Municipal Solid waste	CO 1	T1:3.4, T2:1.4
3	Composition of Municipal Solid waste	CO 1	T1:3.5, R2:1.5
4	Effects of Global warming	CO 1	T1:3.7, R2:1.8
5	Segregation of waste, size reduction and managing waste	CO 1	T1: 3.9, R3: 1.10
6	Waste collection and transfer stations	CO 1	T1:5.5, T2:6.2, R3:4.8
7	Waste minimization and recycling of municipal waste	CO 1	T1:5.6, T2:6.3, R3:7.5
8	Properties of Municipal solid waste	CO 1	T1:4.3, T2:5.2, R2: 5.7

9	Incineration, furnace type and design	CO 1	T1: 4.4, R1:3.3
10	Measures to mitigate environmental effects due to incineration	CO 1	T1:4.5, T2: 5.4, R3: 7.3
11	Land fill methods and disposal of solid waste	CO 2	T1:4.6, T2:5.5
12	land fill classification	CO 2	T1: 4.5.2, T2: 5.6
13	Landfill sitting consideration	CO 2	T1:4.6, T2:5.5
14	Layout and preliminary design of landfills	CO 2	T1:4.6.2, T2:5.5.2
15	Characteristics and composition of landfill	CO 2	T1:4.7, T2:5.6
16	Movement and control of landfill leachate and gases	CO 2	T1:4.7, T2:5.8
17	Environmental monitoring system for land fill gases	CO 2	T1:4.7.2, T2:5.8.2
18	Energy generation from waste by bio-chemical conversion	CO 3	T1:4.8, T2:5.9
19	Sources of energy generation from bio solid waste	CO 3	T1:4.9, T2:5.7
20	Anaerobic digestion of sewage and municipal waste	CO 3	T1:6.2, T2:5.6
21	Direct combustion of MSW-refuse derived solid fuel	CO 3	T1:6.3, T2:5.7
22	Industrial waste, agro residues and anaerobic digestion	CO 3	T1:6.4, T2:5.8
23	Biogas production	CO 3	T1:6.5, T2:5.3
24	land fill gas generation and utilization	CO 3	T1:6..6, T2:5.2
25	Thermo-chemical conversion	CO 4	T1:6.7, T2:5.3
26	Sources of energy generation	CO 4	T1:6.5, T2:7.5
27	Gasification of waste using gasifies briquetting	CO 4	T1: 6.2, R2:7.9
28	Utilization and advantages of briquetting	CO 4	T1: 6.2
29	Environmental benefits of bio-chemical	CO 4	T1:6.2, T2:7.2
30	E-waste in the global context	CO 5	T1:6.3, T2:7.3

31	Growth of electrical and electronics industry in India	CO 5	T1:6.4, T2:7.5
32	Environmental concerns and health hazards	CO 5	T1: 6.2, T2: 5.6
33	Recycling e-waste	CO 5	T1:6.3, T2: 5.7
34	A thriving economy of the unorganized sector and global trade in hazardous waste	CO 5	T1:6.4, T2:5.8
35	Impact of hazardous e-waste in India	CO 5	T1:2.1, T2:9.1
36	Management of e-waste	CO 5	T1:2.2, T2:9.2
37	E-waste legislation	CO 5	T1: 2.1, R2: 9.1
38	Government regulations on e-waste management	CO 5	T1:2.6, R1:5.1
39	International experience in management of e-waste	CO 6	T1:2.7, R1:5.2
40	Need for stringent health safeguards and environmental protection laws of India.	CO 6	T1:2.8, R1:5.5
41	Summarize government regulations on E-waste management	CO 6	T1:2.1, R1:5.6
42	Outline international E-waste management and the guidelines imposed for formal disposal	CO 6	T1:2.2, R1:5.4
43	Explain the need for stringent health safeguards of human health and their effects	CO 6	T1:2.4,R1:5
44	Discuss the need for environmental protection laws and	CO 6	T1:2.4, R1:5.5
45	Outline environmental protection laws of India with respect to E-waste management.	CO 6	T1:2.4, R1:5.5
PROBLEM SOLVING/ CASE STUDIES			
1	Explain different Types of Municipal Solid waste	CO 1	T1:3.3, T2:1.2, R2: 2.2
2	Explain the Composition of Municipal Solid waste	CO 1	T1:3.4, T2:1.4
3	Effects of Global warming	CO 1	T1:3.5,R2:1.5
4	Illustrate the importance of Land fill classification	CO 2	T1:4.5, T2: 5.4, R3: 7.3
5	Landfill sitting consideration	CO 2	T1:4.6, T2:5.5
6	Layout and preliminary design of landfills	CO 2	T1: 4.5.2, T2: 5.6

7	Anaerobic digestion of sewage and municipal waste	CO 3	T1:4.6, T2:5.5
8	Direct combustion of MSW-refuse derived solid fuel	CO 3	T1:4.6.2, T2:5.5.2
9	Industrial waste, agro residues and anaerobic digestion	CO 3	T1:4.7, T2:5.6
10	Explain the Thermo-chemical conversion	CO 4	T1:4.7, T2:5.8
11	E-waste in the global context	CO 5	T1:4.7.2, T2:5.8.2
12	Growth of electrical and electronics industry in India	CO 5	T1:4.7.2, T2:5.8.2
13	E-waste legislation	CO 5	T1:4.8, T2:5.9
14	Government regulations on e-waste management	CO 6	T1:4.9, T2:5.7
15	International experience in management of e-waste	CO 6	T1:6.3, T2: 5.7
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Solid waste sources solid waste sources, types, composition, properties, Municipal solid waste: Physical, chemical and biological properties, waste collection and, transfer stations, waste minimization and recycling of municipal waste, environmental impacts, measures to mitigate environmental effects due to incineration	CO 1	T1:1.5, T2: 5.4, R3: 7.3
2	Land fill method of solid waste, classification, types, methods and sitting consideration; Layout and preliminary design of landfills: Composition, characteristics, generation, movement and control of landfill leachate and gases, environmental monitoring system for land fill gases.	CO 2	T1:4.5, T2: 5.4, R3: 7.2
3	Energy generation from waste bio-chemical conversion: Sources of energy generation, anaerobic digestion of sewage and municipal waste, direct combustion of MSW-refuse derived solid fuel. Industrial waste, agro residues and anaerobic digestion.	CO 3	T1:4.5, T2: 5.4, R3: 7.3
4	Biogas production, land fill gas generation and utilization, thermo-chemical conversion:gasification of waste using gasifies briquetting, utilization and advantages of briquetting, environmental benefits of bio-chemical and thermo- chemical conversion	CO 4	T1:4.5, T2: 5.4, R3: 7.3

5	E-waste in the global context: Growth of electrical and electronics industry in India, environmental concerns and health hazards; global trade in hazardous waste, Management of e-waste, legislation, government regulations on e-waste management, international experience and environmental protection laws of India	CO 5	T1:4.5, T2: 5.4, R3: 7.3
DISCUSSION OF QUESTION BANK			
1	Introduction to Waste and Waste Processing	CO 1	T1:3.3, T2:1.2, R2: 2.2
2	Waste Treatment and Disposal	CO 2	T 1.4:7.3
3	Bio-Chemical Conversion	CO 3	T1:6.2, T2:5.6
4	Thermo-Chemical Conversion	CO 4	T1:6.7, T2:5.3
5	E-Waste Management	CO 5, CO 6	T1:2.4, R1:5.5

Signature of Course Coordinator **HOD, CE**
Mr. CH. Balakrishna, Assistant Professor

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**CAD / CIM**				
Course Code	AAE521				
Program	B.Tech				
Semester	VIII				
Course Type	Elective				
Regulation	R 16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr.D.Govardhan, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME102	II	Computer Aided Engineering Drawing Practice
B.Tech	AAE005	IV	Aircraft Materials and Production
B.Tech	AAE110	VI	Computer Aided Manufacturing Laboratory

II COURSE OVERVIEW:

Computer aided Design/ Computer Integrated Manufacturing (CAD/CIM) is to impart the overview of computer applications or design and manufacturing the discrete engine components, assemblies and final product to meet the global competition. The course covers the life cycle of a product , product model generation. It imposes the knowledge of latest manufacturing techniques using Group technology computer aided process planning, computer aided planning and control, shop floor control and introduction to FMS, computer monitoring . It makes the student to understand the modern inspection methods and concepts of CIM.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
CAD/CIM	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

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

Component	Theory		Total Marks
Type of Assessment	CIE Exam	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 below table

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

VI COURSE OBJECTIVES:

The students will try to learn:

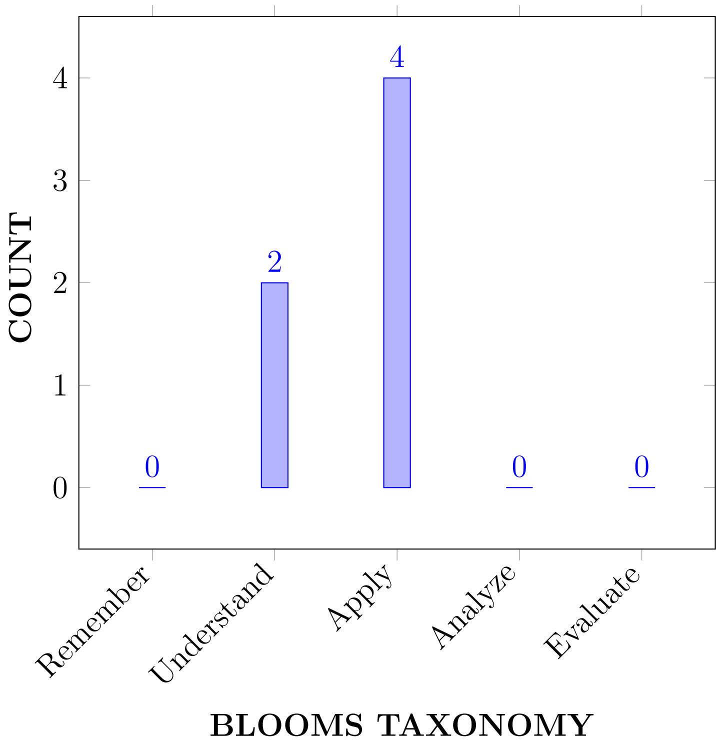
I	Understand the basics of computer aided designing, computer aided manufacturing and computer integrated manufacturing.
II	To study about group technology, computer aided process planning, material requirement planning (MRP) Enterprise resource planning (ERP).
III	Gain knowledge about shop floor control and Flexible manufacturing systems (F.M.S)
IV	Emphasizes the integration of manufacturing enterprise using computer integrated manufacturing (CIM) technologies.

VII COURSE OUTCOMES:

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

CO 1	**Illustrate** the integration of CAD, CAM and other systems with support of hardware and software for product life cycle management .	Understand
CO 2	**Make use of** geometric models, curve representation and surface representation to generate solid modelling.	Apply
CO 3	**Develop** NC part program data using manual data input (MDI) and automatically using standard commercial CAM package for manufacturing of required component using CNC milling or turning applications.	Apply
CO 4	**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.	Understand
CO 5	**Apply** the different quality control methods and various contact and non-contact inspection methods used in various manufacturing systems.	Apply
CO 6	**Organize** the computer controlled monitoring and material handling management system for computer integrated manufacturing systems.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and 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	Presentation on real-world 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.	2	Seminar
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 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/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/SEE/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	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	Use the knowledge of **engineering fundamentals, basic structure of CAD workstation(Own Discipline)** and **understanding the device requirements (Own Discipline)** to select appropriate tools for the desired profile.	3
	PO 2	**Identify the tools** available that canthat can be manufactured using CNC machinery and **Generate and interpret engineering technical drawings** of parts and assemblies according to design standards.	2
	PO 12	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 3	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.	2
CO 2	PO 1	Explain (understanding) different joining process (apply) in producing shapes of objects by applying the principles of science and engineering fundamentals.	3
	PO2	Understand the (complex) impact of the professional engineering solutions societal and environmental contexts and demonstrate the(knowledge) of, and need for sustainable development	2
	PO 3	Understand the (complex) impact of the professional engineering solutions societal and environmental contexts and demonstrate the(knowledge) of, and need for sustainable development	2
	PO 5	Understand the (complex) impact of the professional engineering solutions societal and environmental contexts and demonstrate the(knowledge) of, and need for sustainable development	2
	PO 12	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 3	Apply (knowledge) of casting and welding process in solving aircraft designing problems by applying the principles of science and Engineering	2
CO 3	PO 1	Identify(apply) different sheet metal process in producing (complex) shapes of objects by applying the principles of science and engineering fundamentals.	3
	PO 2	Identify(apply) different sheet metal process in producing (complex) shapes of objects by applying the principles of science and engineering fundamentals.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 3	Identify(apply) different sheet metal process in producing (complex) shapes of objects by applying the principles of science and engineering fundamentals.	2
	PO 5	Identify(apply) different sheet metal process in producing (complex) shapes of objects by applying the principles of science and engineering fundamentals.	2
	PO 12	Identify(apply) different sheet metal process in producing (complex) shapes of objects by applying the principles of science and engineering fundamentals.	2
	PSO 3	Apply (knowledge) sheet metal process for making aircraft components by applying the principles of science and Engineering .	2
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 science and engineering fundamentals.	3
	PO 2	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 3	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 5	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 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.	2
	PSO 3	choose the machine tools for making aircraft components(understanding) by applying the principles of science and Engineering.	2
CO 5	PO 1	Apply (knowledge) of CNC machines (understanding) in manufacturing process (apply) for production of aircraft components by applying the principles of science and Engineering.	3
	PO 2	Apply (knowledge) of CNC machines (understanding) in manufacturing process (apply) for production of aircraft components by applying the principles of science and Engineering.	2
	PO 3	Apply (knowledge) of CNC machines (understanding) in manufacturing process (apply) for production of aircraft components by applying the principles of science and Engineering.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 5	Apply (knowledge) of CNC machines (understanding) in manufacturing process (apply) for production of aircraft components by applying the principles of science and Engineering.	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.	2
	PSO 3	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.	2
CO 6	PO 1	Recognize (knowledge) the materials and their processing (understanding), subjected to various loading conditions (apply) in solving aircraft designing problems by applying the principles of science and Engineering fundamentals.	3
	PO 2	Understand the (complex) impact of the professional engineering solutions societal and environmental contexts and demonstrate the(knowledge) of, and need for sustainable development	2
	PO 3	Understand the (complex) impact of the professional engineering solutions societal and environmental contexts and demonstrate the(knowledge) of, and need for sustainable development	2
	PO 5	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.	2
	PSO3	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.	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
CO 2	3	-	2	-	2	-	-	-	-	-	-	2	-	-	2
CO 3	3	-	-	-	2	-	-	-	-	-	-	2	-	-	2

CO 4	3	-	-	-	2	-	-	-	-	-	-	2	-	-	2
CO 5	3	-	-	-	2	-	-	-	-	-	-	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	66.6	-	-	-	-	-	-	-	-	-	66.6	-	-	66.6
CO 2	100	-	66.6	-	66.6	-	-	-	-	-	-	66.6	-	-	66.6
CO 3	100	-	-	-	66.6	-	-	-	-	-	-	66.6	-	-	66.6
CO 4	100	-	-	-	66.6	-	-	-	-	-	-	66.6	-	-	66.6
CO 5	100	-	-	-	66.6	-	-	-	-	-	-	66.6	-	-	66.6
CO 6	100	-	-	-	66.6	-	-	-	-	-	-	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
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	-	2	-	-	-	-	-	-	2	-	-	2
CO 3	3	-	-	-	2	-	-	-	-	-	-	2	-	-	2
CO 4	3	-	-	-	2	-	-	-	-	-	-	2	-	-	2
CO 5	3	-	-	-	2	-	-	-	-	-	-	2	-	-	2
CO 6	3	-	-	-	2	-	-	-	-	-	-	2	-	-	2
TOTAL	18	2	2	-	10	-	-	-	-	-	-	12	-	-	12
AVERAGE	3	2	2	-	2	-	-	-	-	-	-	2	-	-	2

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	INTRODUCTION
	Computers in industrial manufacturing , product cycle, CAD/CAM hardware, basic structure, CPU, memory types, input devices, display devices, hard copy devices, and storage devices, computer graphics, raster scan graphics coordinate system, database structure for graphics modeling, transformation of geometry, three dimensional transformations, mathematics of projections, clipping, hidden surface removal.
MODULE II	GEOMETRIC MODELLING
	Requirements, geometric models, geometric construction models, curve representation methods, surface representation methods, modeling facilities desired, drafting and modeling systems, basic geometric commands, layers, display control commands, editing, dimensioning and solid modeling.
MODULE III	GROUP TECHNOLGY COMPUTER AIDED PROCESS PLANNING
	History of group technology, role of G.T in CAD/CAM integration, part families, classification and coding, DCLASS and MCLASS and OPTIZ coding systems, facility design using G.T, benefits of G.T, cellular manufacturing. Process planning, role of process planning in CAD/CAM integration, approaches to computer aided process planning, variant approach and generative approaches, CAPP and CMPP systems.
MODULE IV	COMPUTER AIDED PLANNING AND CONTROL, SHOP FLOOR CONTROL AND INTRODUCTION TO FMS
	Production planning and control, cost planning and control, inventory management, material requirements planning (ERP), control, phases, factory data collection system, automatic identification methods, bar code technology, automated data collection system; FMS, components of FMS, types, FMS workstation, material handling and storage system, FMS layout, computer control systems, applications and benefits.
MODULE V	COMPUTER AIDED PLANNING AND CONTROL AND COMPUTER MONITORING
	Production planning and control, cost planning and control, inventory management, material requirements planning (MRP), shop floor control, lean and agile manufacturing, types of production monitoring systems, structure model of manufacturing, process control and strategies, direct digital control.

TEXTBOOKS

1. A. Zimmers, P. Groover- CAD/ CAM, Prentice- Hall India, 2008.
2. Zeid, Ibrahim, - CAD / CAM Theory and Practice, Tata McGraw-Hill, 1997.
3. Mikell. P.Groover -Automation, Production Systems and Computer Integrated Manufacturing, Pearson Education 2001.
4. Ranky, Paul G. - Computer Integrated Manufacturing, Prentice hall of India Pvt. Ltd.,2005 .
5. Yorem Koren - Computer Integrated Manufacturing, McGraw Hill, 2005.

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1. P. Groover, Automation, - Production Systems and Computer Integrated Manufacturing‖, Pearson Education.2nd Edition 1989.

2. Lalit Narayan, - Computer Aided Design and Manufacturing‖, Prentice-Hall India.3rd Edition 2002. .
3. Radhakrishnan, Subramanian, - CAD / CAM / CIM‖, New Age.4th Edition 2016.
4. Jami J Shah, Martti Mantyla, - Parametric and Feature-Based CAD/CAM: Concepts, Techniques, and Applications‖, John Wiley and Sons Inc, 1995.
5. Alavala, - CAD/ CAM: Concepts and Applications‖, PHI Publications, 4th Edition, 2016.
6. W. S. Seames, - Computer Numerical Control Concepts and Programming‖, 4th Edition 1999.

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	Computers in industrial manufacturing and product cycle	CO 1	T1:5.5 R1:1.12.1
3	CAD/CAM hardware, basic structure, CPU, memory types, input devices, display devices, hard copy devices, and storage devices	CO 1	T2:5.5 R1:1.12.1
4	computer graphics, raster scan graphics coordinate system	CO 1	T2:5.6 R1:1.12.3
5	database structure for graphics modeling	CO 1	T2:5.10 R1:1.15
6	transformation of geometry and three dimensional transformations	CO 1	T2:5.10 R1:1.15
7	mathematics of projections	CO 1	T2:5.15 R1:1.16
8	clipping and hidden surface removal	CO 1	T2:5.17 R1:1.13.1
9	Requirements, geometric models, geometric construction models	CO 2	T2:5.18 R2:1.13.2
10	curve and surface representation methods	CO 2	T2:5.18 R2:1.13.2
11	Desired modeling facilities	CO2	T3:5.19 R2:1.13.3
12	drafting and modeling systems	CO 2	T2:5.20 R1:1.17.1
13	basic geometric commands	CO 2	T3:5.20 R2:1.17.1
14	layers, display control commands	CO 2	T3:5.24 R2:1.17.3
15	editing, dimensioning and solid modeling	CO 2	T2:6.1R1:2.3
16	History of group technology	CO 3	T3:6.3 R1:2.6.1
17	role of G.T in CAD/CAM integration	CO 3	T2:6.5 R1:2.6.2
18	part families	CO 3	T2:7.3 R1:2.8

19	classification and coding	CO 3	T2:7.3 R1:2.8
20	DCLASS and MCLASSc	CO 3	T2:7.5,7.6 R1:2.9.2
21	OPTIZ coding systems	CO 3	T2:7.7 R1:2.10
22	facility design using G.T and benefits of G.T	CO 3	T2:7.7 R1:2.10
23	cellular manufacturing	CO 3	T2:7.7 R1:2.10
24	Process planning, role of process planning in CAD/CAM integration	CO 4	T1:7.7 R1:2.10
25	approaches to computer aided process planning , variant approach and generative approaches	CO 4	T2:7.11 R2:2.10.2
26	CAPP and CMPP systems	CO 4	T2:7.11 R2:2.10.2
27	Production planning and control, cost planning and control, inventory management	CO 5	T2:7.11 R1:2.32
28	material requirements planning (ERP), control, phases, factory data collection system, automatic identification methods.	CO 5	T2:7.11 R1:2.32
29	bar code technology, automated data collection system	CO 5	T2:15.2 R1:8.2
30	types ,Layout and components of FMS,material handling and storage system	CO 5	T2:15.7 R2:8.3.3
31	applications and benefits of computer control systems	CO 5	T2:15.13 R1:8.7.2
32	Production planning and control	CO 6	T2:5.20 R1:1.17.1
33	cost planning and control, inventory management	CO 6	T3:6.1 R1:2.3
34	material requirements planning (MRP)	CO 6	T3:6.1 R1:2.3
35	shop floor control, lean and agile manufacturing	CO 6	T2:6.3 R3:2.6.1
36	types of production monitoring systems	CO 6	T2:6.5 R1:2.6.2
37	Materials used for aircraft components	CO 6	T2:7.3 R1:2.8
38	structure model of manufacturingl	CO 6	T2:7.3 R1:2.8
39	process control and strategies	CO 6	T3:7.5,7.6 R3:2.9.2
40	direct digital control	CO 6	T3:7.7 R3:2.10
PROBLEM SOLVING/ CASE STUDIES			
1	Discuss the applications of CAD and CAM in the manufacturing environment with examples.	CO 1	T2:5.6 R1:1.12.3
2	Elaborate Raster Scan Graphics scanning method with sketches in details.	CO 1	T2:5.6 R1:1.12.3
3	Briefly explain various methods of clipping.?	CO 1	T2:5.10 R1:1.15
4	Explain Bezier equation with algorithm and the method of construction of curve from trajectory lines.	CO 2	T2:5.18 R2:1.13.2
5	Compare line, surface and solid modeling in every aspect for industrial applications with examples.	CO 2	T2:5.20 R1:1.17.1
6	Enumerate various desired modeling facilities required for Industries.	CO 2	T2:6.3 R1:2.6.1
7	Explain Part families and classification methods in Group Technology	CO 3	T2:6.5 R1:2.6.2
8	Discuss about MICLASS and DCLASS classification and coding system.	CO 3	T2:7.7 R1:2.10

9	Briefly discuss the various benefits of implementing a GT in a firm. Also bring out the advantages and limitations of using GT.	CO 3	T2:7.7 R1:2.10
10	Explain computer aided process planning with steps involved	CO 4	T2:7.11 R1:2.32
11	Detail out the Variant approach and generative approaches in CAPP.	CO 4	T2:15.13 R1:8.7.2
12	Draw a typical FMS layout for automobile manufacturing.	CO 5	T2:5.20 R1:1.17.1
13	Discuss the types of material handling systems.	CO56	T2:7.3 R1:2.8
14	Explaination of lean and agile manufacturing.	CO 6	T2:6.5 R1:2.6.2
15	Describe the process of Cellular Manufacturing	CO 6	T2:6.5 R1:2.6.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	principle of Rasterscan graphics,product life cycle, data storage devices and clipping	CO 1	T2:5.6 R1:1.12.3
2	Geometric Model,constraint based modeling,wire frame model,Bezier curve	CO 2	T2:5.18 R2:1.13.2
3	Se DCLASS and OPTIZ methods,CAPP and CMPP systems	CO 3,4	T2:6.5 R1:2.6.2
4	e strength and weakness of Flexible Manufacturing Systems,Types and applications	CO 4,5	T2:7.11 R2:2.10.2
5	material requirements planning ,inventory management	CO 6	T2:6.3 R3:2.6.1
DISCUSSION OF QUESTION BANK			
1	Explain co-ordinate transformation matrix with neat sketch.	CO 1	T2:5.10 R1:1.15
2	Bezier equation with algorithm and the method of construction of curve from trajectory lines.	CO 2	T2:6.1 R1:2.3
3	Explain Part families and classification methods in Group Technology and computer aided process planning with steps involved.	CO 3,4	T2:7.3 R1:2.8
4	A typical FMS layout for aircraft manufacturing	CO 4,5	T2:7.11 R1:2.32
5	Expalin the inputs to MRP with block diagram	CO 6	T2:6.3 R3:2.6.1

Signature of Course Coordinator **HOD,AE**
Dr. D.Govardhan, Professor

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**FLIGHT CONTROL THEORY**				
Course Code	AAE018				
Program	B.Tech				
Semester	Eight				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms.Sarswati Suryawanshi				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS003	II	Computational Mathematics and Integral Calculus
B.Tech	AEE018	III	Basic Electrical and Electronics Engineering
B.Tech	AAE010	V	Aircraft Systems and Control

II COURSE OVERVIEW:

Flight control system of an aircraft is instrumental in establishing stability of the aircraft through control surfaces. This course introduces the concepts of the control system theory such as transfer functions, step response and impulse response. This course covers stability, feedback and different techniques used for control systems analysis. The course emphasizes on the flight control systems, response analysis for control surface inputs and control augmentation systems such as autopilots.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Flight Control Theory	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
20%	Understand
60 %	Apply
20 %	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:

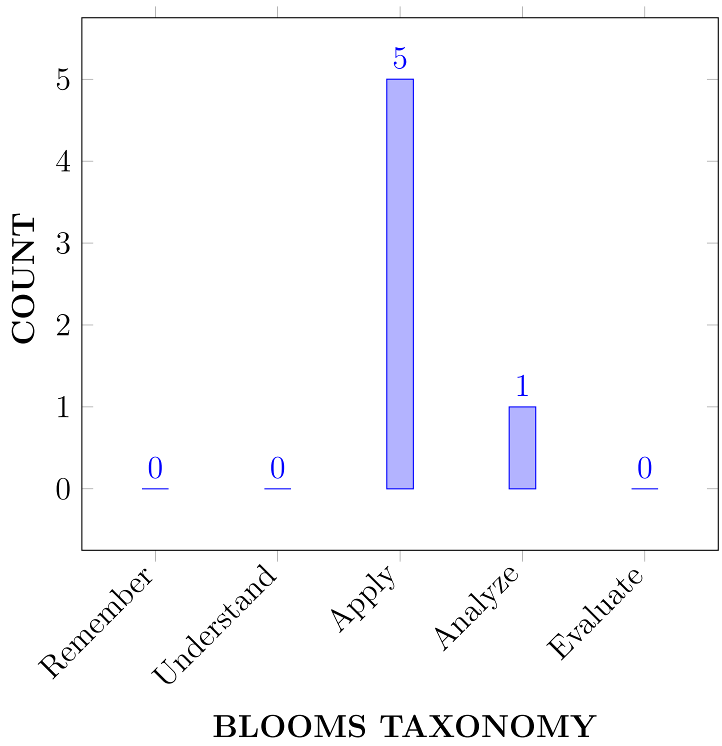
I	The concepts of Classical and modern control theory for selection of suitable control system for aircraft.
II	The stability criteria of an aircraft, the aircraft response specifications and control system parameters.
III	The controllability and observability of aerospace systems, and apply the modern control techniques to enhance flight control systems

VII COURSE OUTCOMES:

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

CO 1	**Develop** the first, second and higher order systems using differential equations	Apply
CO 2	**Utilize** Fourier and Laplace transforms for modeling of dynamical systems and its responses to control inputs.	Apply
CO 3	**Choose** control problems the method for static control of aircraft and its extension to dynamic control	Apply
CO 4	**Analyze** different types of automatic control systems to damp undesirable tendencies of aircraft.	Analyze
CO 5	**Make use of** reversible and irreversible flight control systems to select the suitable flight control system.	Apply
CO 6	**Identify** flying qualities of aircraft in relation to aircraft transfer function with frequency and time response specification.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/CIE/AAT/Quiz
PO 2	**Problem 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/Quiz

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
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		
	PO 1	PO 2	PO 3	PO 4	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 basic concepts of Control Theory using the **knowledge of scientific principles, mathematical principles and other engineering disciplines(basic of electrical and electronics)**	2
CO 2	PO 1	**Demonstrate** first, second and higher order systems by **applying the knowledge of mathematics (differential equations), scientific principles and engineering specialization.**	2
	PO 2	**Identify** the problem of representation of control system(first, second and higher) in mathematical form and **formulate using mathematical principles (differential equation)**	2
	PO 3	**Design and development of solution** Use research-based knowledge and research methods including **design of experiments,and analysis of data related to the automatic control of aircraft with control auto stabilization**.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 2	Make use of 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 3	PO 1	**Understand** the basic concepts of Control Theory using the **knowledge of scientific principles, mathematical principles and other engineering disciplines(basic of electrical and electronics)**	2
	PO 2	**Identify** the problem of representation of control system(first, second and higher) in mathematical form and **formulate using mathematical principles (differential equation)**	2
	PSO 3	Understand the characteristics of aircraft longitudinal / lateral control by using modern tool to go further one level to become **entrepreneur**.	3
CO 4	PO 1	**Demonstrate** first, second and higher order systems by **applying the knowledge of mathematics (differential equations), scientific principles and engineering specialization.**	2
	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**.	3
CO 5	PO 1	Recall **the knowledge of mathematics, scientific principle and engineering specialization** to **explain** control system components	2
	PO 2	**Identify** the problem of representation of control system(first, second and higher) in mathematical form and **formulate using mathematical principles (differential equation)**	2
	PO 3	**Design and development of solution** Use research-based knowledge and research methods including **design of experiments,and analysis of data related to the automatic control of aircraft with control auto stabilization**.	2
	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	Use **the basics of mathematics (differential equation, Laplace and flourier transform), scientific principles and engineering fundamentals** classify control problems for aircraft.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	**Identify** the problem of representation of control system(first, second and higher) in mathematical form and **formulate using mathematical principles (differential equation)**	2
	PSO 3	Understand the characteristics of aircraft longitudinal / lateral control by using modern tool to go further one level to become **entrepreneur**.	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	2	2	-	-	-	-	-	-	-	-	-	-	2	-
CO 3	2	2	-	-	-	-	-	-	-	-	-	-	-	-	3
CO 4	2	-	-	-		-	-	-	-	-	-	-	-	3	-
CO 5	2	2	2	-	-	-	-	-	-	-	-	-	-	2	-
CO 6	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	67	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	67	20	20	-	-	-	-	-	-	-	-	-	-	67	-
CO 3	67	20	-	-	-	-	-	-	-	-	-	-	-	-	100
CO 4	67	-	-	-		-	-	-	-	-	-		-	67	-
CO 5	67	20	20	-	-	-	-	-	-	-	-	-	-	67	-
CO 6	67	20	-	-		-	-	-	-	-	-		-	-	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	1	1	-	-	-	-	-	-	-	-	-	-	2	-

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	PO1,PO2, PSO2	SEE Exams	PO1,PO2	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 1	Open Ended Experiments	-
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO CONTROL SYSTEMS**
	Dynamical systems-principal constituents-input, output-process (plant)-block diagram representation. Inputs- control input, noise. Function of controls regulation (hold), tracking (command)-examples. Measure of effectiveness. Sensitivity of output to control input, noise and system parameters-robustness. Deterministic and stochastic control. Control in everyday life. The pervasiveness of control in nature, engineering and societal systems. The importance of study of control system. Need for a stable, effective (responsive), robust control system. Modeling of dynamical systems by differential equations-system parameters. Examples from diverse fields. First and second order systems, higher order systems, single input single output systems, and multiple-input multiple-output.
MODULE II	**MATHEMATICAL MODELLING OF DYNAMIC SYSTEMS**
	Control system performance- time domain description- output response to control inputs– impulse and indicial response- characteristic parameters-significance- relation to system parameters- examples- first and second order linear systems, higher order systems. Synthesis of response to arbitrary input functions from impulse and indicial response. Review of Fourier transforms and Laplace transforms- inverse transforms- significance, applications to differential equations. 's' (Laplace) domain description of input- output relations- transfer function representation- system parameters- gain, poles and zeroes. Characteristic equation- significance -examples.Frequency and damping ratio of dominant poles. Relation of transfer functions to impulse response. Partial fraction decomposition of transfer functions-significance

MODULE III	**STEADY STATE RESPONSE ANALYSIS**
	System type, steady state error, error constants- overall system stability. Application of feedback in stability augmentation, control augmentation, automatic control-examples. Composition, reduction of block diagrams of complex systems-rules and conventions. Control system components - sensors, transducers, servomotors, actuators, filters-modeling, transfer functions. Single-input single-output systems. Multiple input-multiple output systems, matrix transfer functions-examples. Types of control problems- the problem of analysis, control synthesis, system synthesis- examples- static control of aircraft. Extension to dynamic control. System identification from input output measurements importance. Experimental determination of system transfer functions by frequency response measurements. Example. Frequency domain description- frequency response- gain and phase shift- significance-representation asymptotic (Bode) plots, polar (Nyquist) plots, frequency transfer functions. Characteristic parameters corner frequencies, resonant frequencies, peak gain, and bandwidth- significance. First and second order systems- extension to higher order systems.
MODULE IV	**AIRCRAFT RESPONSE TO CONTROLS**
	Approximations to aircraft transfer functions, control surface actuators-review. Response of aircraft to elevator input, Response of aircraft to rudder input and Response of aircraft to aileron input to atmosphere. Need for automatic control. Autopilots Stability augmentation systems-pitch damper and yaw damper
MODULE V	**FLYING QUALITIES OF AIRCRAFT**
	Reversible and irreversible flight control systems. Flying qualities of aircraft-relation to airframe transfer function. Pilot's opinion ratings. Flying quality requirements- pole-zero, frequency response and time- response specifications. Displacement and rate feedback determination of gains conflict with pilot input s resolution-control augmentation systems- Full authority fly-by-wire. AutoPilot-Normal acceleration,Turn rate, Pitch rate Commands-Applications.

TEXTBOOKS

1. Kuo, B.C., —Automatic Control Systems, Prentice Hall India,1992.
2. Stevens, B.L. and Lewi.s, F.L., —Aircraft Control and Simulation, John Wiley,1992.

REFERENCE BOOKS:

1. Mc Lean, D., —Automatic Flight Control Systems, Prentice Hall, 1990J.
2. Bryson, A.E., —Control of Aircraft and Spacecraft, Princeton University Press,1994.
3. E H J Pallett, Shawn Coyle —Automatic Flight Control, 4th Edition,2002.

WEB REFERENCES:

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

COURSE WEB PAGE:

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Course discrption		
CONTENT DELIVERY (THEORY)			
1	Dynamical systems-principal constituents	CO1	T1:1-1-1
2	Input, output-process (plant)-block diagram. Inputs- control input, noise Function of controls regulation (hold), tracking (command)-examples	CO1	T1:3-1-1 T2:5.4
3	Measure of effectiveness. Sensitivity of output to control input, noise and system parameters- robustness	CO1	T1:1.2
4	Deterministic and stochastic control. Control in everyday life	CO1	T1:1.2
5	The pervasiveness of control in nature, engineering and societal systems. The importance of study of control system	CO1	T1:1.1
6	Need for stable, effective (responsive), robust control system	CO1	T1:1.1
7	Modeling of dynamical systems by differential equations-system parameters	CO2	T1:4-1
8	Examples from diverse fields for modeling of dynamical system	CO2	T1:4-2- T1:4-5
9	First and second order systems, higher order systems	CO2	T1:2-3
10	Single input single output systems, and multiple-input multiple-output	CO2	T1:2-7
11	Control system performance- time domain description- output response to control inputs	CO2	T1:5-1- T1:5-3
12	Impulse and indicial response- characteristic parameters- significance- relation to system parameters	CO2	T1:2-7 T1:5-2 T1:5-3
13	Examples- first and second order linear systems, higher order systems	CO2	T1:5-5 T1:5-6
14	Synthesis of response to arbitrary input functions from impulse response, indicial response	CO3	T1:2-7
15	Review of Fourier transforms - significance, applications to differential equations	CO3	T1:2-3
16	Review of Laplace transforms- inverse transforms- significance, applications to differential equations	CO4	T1:2-4
17	's' (Laplace) domain description of input- output relations -transfer function representation- gain, poles and zeroes	CO3	T1:2-2
18	Characteristic equation- significance- examples	CO3	T1:2-3- T1:2-7
19	Frequency and damping ratio of dominant poles.	CO3	T1:2-2
20	Relation of transfer functions to impulse response. Partial fraction decomposition of transfer functions- significance	CO4	T1:2-7 T1:2-5
21	System type, steady state error, error constants- overall system stability. Application of feedback in stability augmentation, control augmentation, automatic control-examples	CO4	T:5-4

22	Composition, reduction of block diagrams of complex systems-rules and conventions	CO4	T1:3-1-3
23	Control system components - sensors, transducers, servomotors, actuators, filters-modeling, transfer functions	CO5	T1:4-6
24	Single-input single-output systems. Multiple input-multiple output systems, matrix transfer functions-examples.	CO5	T1:2-7
25	Types of control problems- the problem of analysis, control synthesis, system synthesis- examples- static control of aircraft. Extension to dynamic control	CO5	T1:4-1-T1:4-8
26	System identification from input output measurements importance	CO5	T1:4-1-T1:4-8
27	Experimental determination of system transfer functions by frequency response measurements. Example	CO5	T1:5
28	Frequency domain description- frequency response- gain and phase shift- significance	CO5	T1:5
29	Representation asymptotic (Bode) plots, polar (Nyquist) plots, frequency transfer functions.	CO5	T1:2-2
30	Characteristic parameters corner frequencies, resonant frequencies, peak gain, and bandwidth- significance	CO5	T1:2-3
31	First and second order systems- extension to higher order systems	CO5	T1:2-4
32	Approximations to aircraft transfer functions	CO6	T2:3.1-3.8 R2:3.2
33	Control surface actuators-review	CO6	T2:4.1-4.2 R2:3.2
34	Response of aircraft to elevator input, Response of aircraft to rudder input and Response of aircraft to aileron input to atmosphere	CO 6	T2:4.2-4.3 R2:3.2
35	Need for automatic control	CO 6	T2:4.6
36	Autopilots Stability augmentation systems-pitch damper	CO 6	T2:4.4-4.5 R2:3.2
37	Autopilots Stability augmentation systems- yaw damper	CO 6	T2:4.4-4.5 R2:3.2
38	Reversible and irreversible flight control systems	CO 6	T2:4.7
39	Flying qualities of aircraft-relation to airframe transfer function. Pilot's opinion ratings	CO 6	T2:3.1-3.3 R1:5.2
40	Flying quality requirements- pole-zero	CO 6	T2:6.1 R1:5.2
PROBLEM SOLVING/ CASE STUDIES			
1	Flying quality requirements- frequency response and time-response specifications	CO1	T2:6.2 R15:2
2	Displacement and rate feedback determination of gains conflict with pilot inputs resolution	CO 1	T2:6.3 R15:5

3	Control augmentation systems- Full authority fly-by-wire.	CO 2	T2:4.5 R2:3.6
4	Fly by wire system	CO 6	T2:6.1
5	Case study on Auto Pilot-Normal acceleration, Turn rate, Pitch rate Commands	CO 2	T2:4.6 T2:5.4
6	Mathematical Modeling of Laplace transformation.	CO3	T1:2-2
7	Modeling of Characteristic equation- significance.	CO3	T1:2-3- T1:2-7
8	Frequency and damping ratio of dominant poles.	CO2	T1:2-2
9	Relation of transfer functions to impulse response.	CO4	T1:2-7 T1:2-5
10	case study on error constants- overall system stability.	CO2	T:5-4
11	Composition, reduction of block diagrams of complex systems-rules and conventions	CO5	T1:3-1-3
12	Case study on - sensors, transducers, servomotors, actuators, filters-modeling, transfer functions	CO5	T1:4-6
13	Modeling of dynamical systems by differential equations-system parameters	CO6	T1:4-1
14	Examples from diverse fields for modeling of dynamical system	CO6	T1:4-2- T1:4-5
15	Development of fly by wire- a case study	CO6	T1:4-2- T1:4-5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Flying quality requirements- frequency response and time-response specifications	CO 1	T2:6.2 R15:2
2	Displacement and rate feedback determination of gains conflict with pilot inputs resolution	CO2	T2:6.3 R15:5
3	Control augmentation systems- Full authority fly-by-wire.	CO3, 4	T2:4.5 R2:3.6
4	Fly by wire system	CO12	T2:6.1
5	AutoPilot-Normal acceleration, Turn rate, Pitch rate Commands	CO6	T2:4.6 T2:5.4
DISCUSSION OF QUESTION BANK			
1	Historical background for Flight control system	CO 1	R4:2.1
2	Flight control Introduction	CO 2,3	T4:7.3
3	Frequency and damping ratio	CO 4	R4:5.1
4	Control surfaces actuators	CO 5	T1:7.5
5	Autopilot control augmentation	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	**AVIATION MANAGEMENT**				
Course Code	AAE019				
Program	B.Tech				
Semester	Eighth				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms.K.Sai Priyanka				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAE001	III	Introduction To aerospace Engineering
B.Tech	AAE526	VI	Air transportation system

II COURSE OVERVIEW:

The aim is to understanding of relevant international and national regulations and the ability to explain their effects on airport business, planning, design, operations and safety management decisions.A critical awareness of the key issues that affect users of airport facilities.And to identify, analyse and design solutions in order to address a given research problem within the context of airport planning and management, having regard to regulatory constraints and commercial and environmental imperatives.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
AVIATION MANAGEMENT	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
%	Remember
%	Understand
%	Apply
%	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	Understand about the history of aviation, major players airline industry, current trends and challenges.
II	Impart the knowledge on airport planning, airport operation and various authorities involved in airport management.
III	Understand and gain the knowledge on the meteorological services, environmental regulation and airport fee, rates and charges.

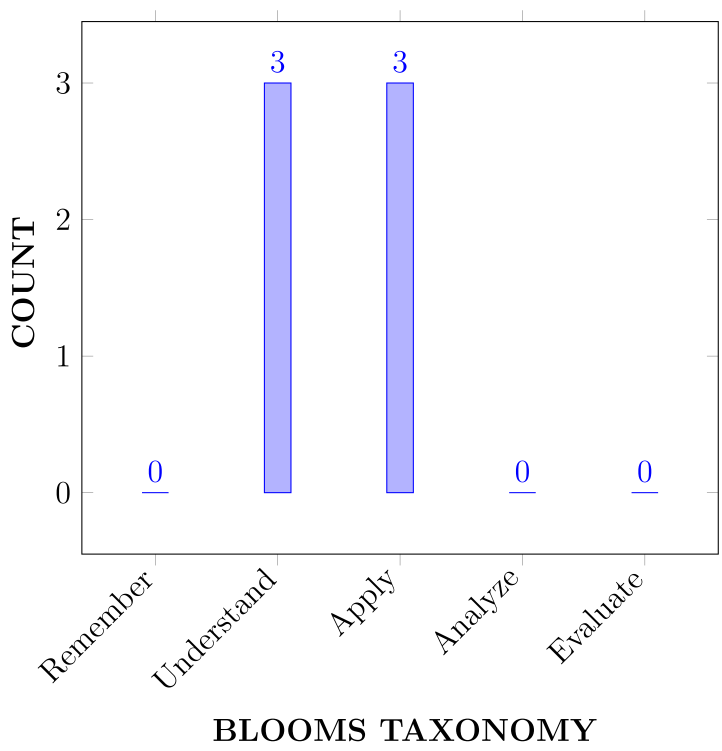
IV	Gain the in depth knowledge on safety regulation, economic regulation and aviation security.

VII COURSE OUTCOMES:

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

CO 1	**Illustrate** the major roles of airport authority of India, current challenges in airline industry for air navigation service (ANS) at the airports, works under the ministry of civil aviation	Understand
CO 2	**Demonstrate** strengths, weaknesses, opportunities, and threats, of Swot analysis at different airline companies for the operations of three broad categories engineering and maintenance, flight operations, and sales and marketing .	Understand
CO 3	**Select** various domestic services and International air transport services from an Indian perspective for most needs of the business aviation system and serve as essential transportationl	Apply
CO 4	**Identify** the roles of the public sector and private sector operators and development fees rates and tariffs for development by promoting rapid economic growth through infrastructure creation and expansion	Apply
CO 5	**Classify** types of privatizations , navigation service provided to civil aviation with the very high frequency, omni range transmitters, ILS, management systems for the signals to en-route flight arrival and departure.	Understand
CO 6	**Utilize** the methodology followed by ATC, economic Regulations, directorate general of civil aviation include for governing safety aspects of civil aviation, which include certification of airlines and aerodromes, airworthiness, licensing and surveillance of aircraft operations	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards.	2	Quiz

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Recall engineering knowledge** of aircraft design, aircraft performance and operating characteristics by using **the principles of mathematics and sciences.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO 3	**Recall knowledge of engineering** for explaining the concepts of maintenance of aircraft (with associated systemsby using**mathematical and scientific principles .)**	3
	PSO1 2	**Able** to utilize the **knowledge of aeronautical/ aerospace engineering differential equation**for occupational safety and health administration agency**for occupational safety and health administration.**	5
CO 3	PO 1	**Understand the fundamentals principles** of climbing and descent performance for best climb of climbing and descent performance for best climb **by using engineering knowledge and scientific principles.**	3
	PSO1 2	**Able** to utilize the **knowledge of aeronautical/ aerospace engineering differential equation**for occupational safety and health administration agency**for occupational safety and health administration.**	5
CO 4	PO 1	**Apply the engineering knowledge** of different parts of an aircraft using principles of mathematics, science, and engineering fundamentals **organizational strategies employed by airport management**	3
	PO3	**Developing** to utilize the **the concept of airport development** principles of mathematics, science, and engineering fundamentals **of the Full privatization-Gradual privatization**	5
CO 5	PO 1	**Explain** the evolution of the global air freight industry by **applying the knowledge of Mathematics, Sciences and Engineering fundamentals including the development of the integrated cargo carriers.**	3
CO 6	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** of various hazard identification and risk management tools **tools in safety and security program management.**	3
	PO3	**Developing** the model of Various Airport service **principles of mathematics, science, and engineering fundamentals for international air transport services.**	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	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-		-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	66	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100		30	-	-	-	-	-	-	-	-	-	-	-	66
CO 4	100	-	-	-		-	-	-	-	-	-		-	66	-
CO 5	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
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	2	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO 2	2	2	-	-	-	-	-	-	-	-	-		-		
CO 3	1	2	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 4	2	0	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 6	2	0	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	12	5	-	-	-	-	-	-	-	-	-	-	-	5	-
AVERAGE	2	1.7	-	-	-	-	-	-	-	-	-	-	-	1.7	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	PO1,PO2, PSO2	SEE Exams	PO1,PO2	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 1	Open Ended Experiments	-
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION**
	History of Aviation- organization, global , social and ethical environment-history of aviation in India-Major players in Airline industry-Swot Analysis of different Airline companies in India- market potential of Airline industry in India- new airport development plans-current challenges in airline industry- competition in Airline industry- Domestic andInternational from an Indian perspective
MODULE II	**AIRPORT INFRASTRUCTURE AND MANAGEMENT**
	Airport planning – Terminal planning design and operation -Airport operations – Airport functions- organization structure in an Airline – Airport Authority of India- comparison of global and Indian Airport management- Role of AAI -Airline privatization – Full privatization- Gradual privatization-partial privatization .
MODULE III	**AIR TRANSPORT SERVICES**
	Various Airport services- international air transport services – Indian Scenario- An overview of Airport in Delhi, Mumbai, Hyderabad and Bangalore. The role of private operators- Airport development fees, Rates and Tariffs
MODULE IV	**INSTITUTIONAL FRAMEWWORK**
	Role of DGCA-Slot allocation -Methodology followed by ATC and DGCA – management of bi-laterals – economic Regulations
MODULE V	**CONTROLLING**
	Role of air traffic control- airspace and navigational aids- control process – case study in airline industry- Mumbai-Delhi airport privatization-Navi Mumbai airport tendering process- six cases in the airline industry

TEXTBOOKS

1. Graham. A —Managing airports - an International Perspective butterworth-heinemann, oxford2001

2. Wells. a. —Airport Planning and Management, 4th edition McGraw-Hill, London2000

REFERENCE BOOKS:

1. Alexander t. wells, seth young, —Principles of Airport management, McGraw-hill 2003Y. V. C.Rao

2. Richard de neufille, —Airport systems: Planning, Design and Management, McGraw-hill London2007

WEB REFERENCES:

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

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
	Course discription		
CONTENT DELIVERY (THEORY)			
1	History of Aviation- organization	CO1	T1:1-1-1
2	Global , social and ethical environment	CO1	T1:3-1-1 T2:5.4
3	History of aviation in India Major players in Airline industry	CO1	T1:1.2
4	Swot Analysis of different Airline companies in Indiat	CO1	T1:1.2
5	Market potential of Airline industry in India	CO2	T1:1.1
6	Discussing different types of plans	CO1	T1:1.1
7	New airport development plans	CO2	T1:4-1
8	Discuss responsibilities of ground handling	CO2	T1:4-2-T1:4-5
9	Discuss responsibilities of ground handling	CO2	T1:2-3
10	Discuss airline and passenger related operations	CO2	T1:2-7
11	Define airport authority	CO3	T1:5-1-T1:5-3
12	Define Federal aviation administration	CO3	T1:5-3
13	Define cargo operations and handling operations	CO3	T1:5-5
14	Discuss technical services of an airport	CO3	T1:2-7
15	International air transport services	CO4	T1:2-3
16	Explain airport access	CO3	T1:2-4
17	Indian Scenario An overview of Airport in Hyderabad Bangalore	CO3	T1:2-2
18	Indian Scenario An overview of Airport in Delhi Mumbai	CO3	T1:2-3-T1:2-7
19	Airport development fees, Rates and Tariffs.	CO4	T1:2-2
20	Role of DGCA Slot allocation	CO4	T1:2-7 T1:2-5
21	International air transport services	CO4	T:5-4
22	Methodology followed by DGCA	CO4	T1:3-1-3
23	Various Airport services	CO4	T1:4-6
24	Role of air traffic control	CO4	T1:2-7
25	Airspace and navigational aids	CO4	T1:4-1-T1:4-8
26	Control process for the air traffic management	CO4	T1:4-1-T1:4-8
27	Six cases in the airline industry.	CO4	T1:5
28	Indian Scenario- An overview of Airport in Delhi, Mumbai, Hyderabad and Bangalore.	CO5	T1:5
29	Air traffic control and communications	CO5	T1:2-2

30	Indian Scenario- An overview of Airport in Chennai	CO5	T1:2-3
31	Airport development fees Tariffs	CO5	T1:2-4
32	Approximations to aircraft transfer functions	CO5	T2:3.1-3.8R2:3.2
33	Control surface actuators review	CO5	T2:4.1-4.2R2:3.2
34	Response of aircraft to elevator input, Response of aircraft to rudder input and Response of aircraft to aileron input to atmosphere	CO5	T2:4.2-4.3R2:3.2
35	Role of DGCA, Slot allocation	CO5	T2:4.6
36	Autopilots Stability augmentation systems-pitch damper	CO5	T2:4.4-4.5R2:3.2
37	Methodology followed by ATCr	CO5	T2:4.4-4.5R2:3.2
38	Constraint Analysis of different Airline companies in India	CO5	T2:4.7
39	Methodology followed by DGCA	CO6	T2:3.1-3.3
40	Airport Traffic Control Tower	CO6	T2:6.1
41	Role of air traffic control	CO6	T2:6.2
42	Role of the three principal types of ATM facilities in a typical flight.	CO6	T2:6.3
43	Airspace and navigational aids	CO6	T2:4.5
44	Control process	CO6	T2:6.1
45	Six cases in the airline industry..	CO6	T2:4.6 T2:5.4
PROBLEM SOLVING/ CASE STUDIES			
1	15 problem solving classes	CO 1	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	INTRODUCTION	CO 1,2, 3	R4:2.1
2	AAIRPORT INFRASTRUCTURE AND MANAGEMENT	CO 1,2, 3	R4:2.1
3	AIR TRANSPORT SERVICES	CO 1,2, 3	R4:2.1
4	INSTITUTIONAL FRAMEWWORK	CO 1,2, 3	R4:2.1
5	CONTROLLING	CO 1,2, 3	R4:2.1
DISCUSSION OF QUESTION BANK			
1	Explain Roles of AAI Airport Authority of India-	CO 1,2, 3	R4:2.1
2	Explain Airport privatization and give example of any Partial Privatization	CO 4	T4:7.3
3	Explain Domestic and International airports from an Indian perspective	CO 6	R4:5.1
4	Explain Methodology followed by ATC	CO 5	T1:7.5
5	Explain about the six cases in the airline industry	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	Mechanism and Machine Design				
Course Code	AAE523				
Program	B.Tech				
Semester	V				
Course Type	ELECTIVE				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	4	-	-
Course Coordinator	Dr. D Govardhan, Professor				

I COURSE PRE-REQUISITES:

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

II COURSE OVERVIEW:

Mechanism and Machine Design is the branch of engineering science, which deals with the study of relative motion between the various parts of machine and forces which act on them which leads to design of machines and parts of a machine. This course also discuss the effects of gyroscopic couple and power transmitting elements such as belt drives, cam and followers, gears and gear trains which play key role in in automobile, aerospace and allied engineering industries, industrial automation, design and construction of modern automatic machines.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Mechanism and Machine Design	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two 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
0%	Remember
0%	Understand
66.6%	Apply
33.3%	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:

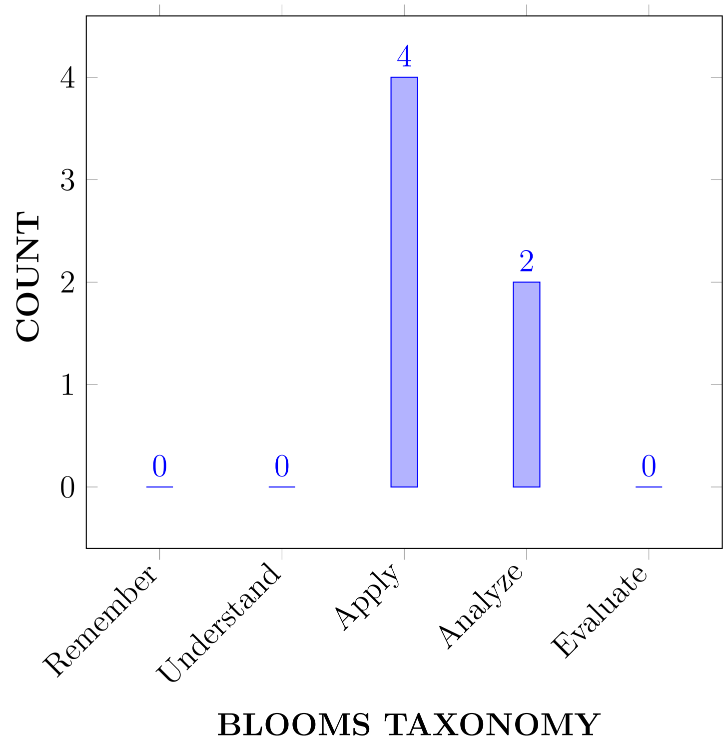
I	The concepts on four bar, single and double slider mechanisms and their inversions in analyzing the relative motions of links for engineering applications.
II	The kinematic analysis of planar mechanisms using instantaneous and relative velocity methods for describing the position, velocity and acceleration of moving links.
III	The effects of gyroscopic couples and rotating masses in designing of aircraft and machine components.
IV	The mechanisms of power transmission among the shafts using cams,toothed gearing and Gear trains in aerospace and aligned engineering industries.

VII COURSE OUTCOMES:

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

CO 1	**Identify** the mechanisms and their inversions based on pairs and joints and mobility of mechanisms using Grumbler's and Grashaf's criterion for studying motion of machine elements in engineering applications.	Apply
CO 2	**Analyze** the planar mechanisms for position, velocity and acceleration using instantaneous center method and graphical approach.	Analyze
CO 3	**Make use of** the effect of gyroscopic couple in moving vehicles for predicting the stability at various speeds	Apply
CO 4	**Choose** the appropriate Cam and Followers for the power transmission with specified motion of follower using cam terminologies for aerospace and allied engineering fields	Apply
CO 5	**Compare** the steering gear mechanisms for the aircraft during ground operation to steer the vehicle in the required direction.	Analyze
CO 6	**Apply** the gear tooth geometry and appropriate gear train for power transmission at desired speeds and design of gear boxes in engineering 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.

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	1	Quiz
PSO 3	Successful career and Entrepreneurship:Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies..	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	Demonstrate (knowledge) the principles of kinematic pairs, chains and their classification to a considerable extent appreciate (understanding) their importance and applicability for planar mechanisms based on pairs and joints by applying the principles of science and Engineering	2
	PO 2	Understand (given problem statement) the principles of kinematic pairs, chains and their classification, Degree of Freedom (complex) for planar mechanisms based on pairs and joints (provided information and data) in reaching substantiated conclusions by the interpretation of results	3
	PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 3	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	2
CO 2	PO 1	Identify (understanding) mechanisms and inversions of kinematic chins, and their mobility using Grumbler's and Grashaf's criterion for engineering applications (apply) in solving (complex) engineering problems by applying the principles of mathematics, science and engineering fundamentals.	3
	PO 2	Understand the (given problem statement) mechanisms and inversions of kinematic chins using Grumbler's and Grashaf's criterion for engineering applications (from the provided information and data) in solving problems of linkage mobility.	3
	PO 2	Understand the (given problem statement) mechanisms and inversions of kinematic chins using Grumbler's and Grashaf's criterion for engineering applications (from the provided information and data) in solving problems of linkage mobility.	3
	PO 3	Understand the (given problem statement) mechanisms and inversions of kinematic chins using Grumbler's and Grashaf's criterion for engineering applications (from the provided information and data) in solving problems of linkage mobility.	3
	PSO 3	Apply (knowledge) Identify the mobility of mechanisms and inversions of kinematic chains (apply) using Grumbler's and Grashaf's criterion for engineering applications by applying the principles of mathematics, science and Engineering	2
CO 3	PO 1	Analyze (understanding) the planar mechanisms for position, velocity and acceleration using instantaneous center method and graphical approach (complex) by applying the principles of mathematics and science	2
	PO 2	Understand (the given problem statement and formulate) the planar mechanisms for position, velocity and acceleration using instantaneous center method and graphical approach (from the provided information and data in reaching substantiated conclusions by the interpretation of results)	4
	PO 3	Analyze (knowledge) the planar mechanisms for position, velocity and acceleration (apply) using instantaneous center method and graphical approach by applying the principles of mathematics, science and Engineering	3
	PSO 3	Apply (knowledge) Identify the mobility of mechanisms and inversions of kinematic chains (apply) using Grumbler's and Grashaf's criterion for engineering applications by applying the principles of mathematics, science and Engineering	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 4	PO 1	Choose (understanding) appropriate belt drives for power transmission between the shafts based on follower rotation for industrial needs (complex) by applying the principles of mathematics, science and engineering fundamentals.	3
	PO 2	Choose the appropriate (given problem statement and formulate) belt drives for power transmission between the shafts based on follower rotation for industrial needs (provided information and data in reaching substantiated conclusions by the interpretation of results)	4
	PO 3	Choose (knowledge) appropriate belt drives for power transmission between the shafts (apply) based on follower rotation for industrial needs by applying the principles of mathematics, science and Engineering	2
	PSO 3	Apply (knowledge) Identify the mobility of mechanisms and inversions of kinematic chains (apply) using Grumbler's and Grashaf's criterion for engineering applications by applying the principles of mathematics, science and Engineering	2
CO 5	PO 1	Identify (knowledge) the displacement diagram of follower and cam profile (apply) for the specified motions of the follower using cam terminologies (complex) by applying the principles of mathematics, science and Engineering	3
	PO 2	Understand (the given problem statement and formulate) the displacement diagram of follower and cam profile (from the provided information and data) for the specified motions of the follower (results) using cam terminologies	4
	PO 3	Choose (knowledge) appropriate belt drives for power transmission between the shafts (apply) based on follower rotation for industrial needs by applying the principles of mathematics, science and Engineering	2
	PSO 3	Identify (knowledge) the displacement diagram of follower and cam profile (apply) for the specified motions of the follower using cam terminologies by applying the principles of mathematics, science and Engineering	2
CO 6	PO 1	Analyze (understanding) speed and torque of simple, compound and epicyclic gear trains (apply) in designing (complex) gear boxes for real field applications by applying the principles of mathematics, science and engineering fundamentals.	3
	PO 2	Identify (the given problem statement and formulate) speed and torque of simple, compound and epicyclic gear trains (from the provided information and data)) for designing gear boxes (results) in real field applications	4

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	50	-	-	-	-	-	-	-	-	-	-	-	40	-
CO 2	100	50	40	-	-	-	-	-	-	-	-	-	-	-	50
CO 3	66.7	50	30	-	-	-	-	-	-	-	-	-	-	-	18
CO 4	100	50	50	-	-	-	-	-	-	-	-	-	-	-	18
CO 5	66.7	20	40	-	-	-	-	-	-	-	-	-	-	-	50
CO 6	66.7	50	-	-	-	-	-	-	-	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	MECHANISMS & MACHINES
	Elements of links, classification, rigid link, flexible and fluid link, types of kinematic pairs, sliding, turning, rolling, screw and spherical pairs, lower and higher pairs, closed and open pairs, constrained motion, completely, partially or successfully constrained, and incompletely constrained, mechanism and machines, classification, kinematic chain, inversion of mechanism, inversion of quadratic cycle, chain, single and double slider crank chains

MODULE II	**KINEMATIC ANALYSIS OF MECHANISMS**
	Instantaneous centre of rotation, centroids and axodes, relative motion between two bodies, three centres in line theorem, graphical determination of instantaneous centre, diagrams for simple mechanisms and determination of angular velocity of points and links. Velocity and acceleration, motion of link in machine, determination of velocity and acceleration diagrams, graphical method, application of relative velocity method for four bar chain, analysis of slider crank chain for displacement, velocity and acceleration
MODULE III	**BELT DRIVES, AND CAMS AND FOLLOWERS**
	Belt Drives: Types of Belts, Material used for Belts, Types of Flat Belt Drives, Velocity Ratio of Belt Drive. Length of Open Belt Drive. Power Transmitted by a Belt. Ratio of Driving Tensions for Flat Belt Drive. Centrifugal Tension. Maximum Tension in the Belt. Initial Tension in the Belt. Cams and followers, definition uses, types, terminology, types of follower motion, uniform velocity, simple harmonic motion and uniform acceleration, maximum velocity and acceleration during outward and return strokes. .
MODULE IV	**GEARS AND GEAR TRAINS**
	Gears And Gear Trains: friction wheels and toothed gears, types, law of gearing, condition for constant velocity ratio for transmission of motion, velocity of sliding, form of teeth, cycloidal and involute profiles, phenomena of interferences.Gear trains: Introduction, types, simple and reverted gear trains, epicyclic gear train; Methods of finding train value or velocity ratio of epicyclic gear trains
MODULE V	**GYROSCOPIC COUPLE AND PRECESSION MOTION AND BALANCING OF ROTATING MASSES**
	Angular Motion: Gyroscopes - Processional Angular Motion; Gyroscopic Couple; effect of precession motion on the stability of moving vehicles such as motorcycle - motorcar - aero planes and ships. Balancing of Rotating Masses;. Balancing of a Single Rotating Mass By a Single Mass Rotating in the same plane; Balancing of a Single rotating mass by two masses rotating in different planes; Balancing of several masses rotating in the same plane; Balancing of several masses rotating in different planes.

TEXTBOOKS

1. Amithab Ghosh, Asok Kumar Malik, "Theory of Mechanisms and machines", East West Press Pvt Ltd, 2001.

2. S.S Ratan, "Theory of Machines", Tata McGraw-Hill, 4th Edition, 2014.

3. J. S. Rao, R.V. Dukkipati "Mechanism and Machine Theory / New Age Publications", 1996.

4. P. L. Ballaney, "Theory of Machines", Khanna Publishers, 3rd Edition, 2003

REFERENCE BOOKS:

1. Dr Jagdish Lal, J. M. Shaw "Theory of Machines", 1st Edition, 1985.

2. Abdulla Sharif, Dhanpat Rai, "Theory of Machines", 5th Edition, 1987,

3. Neil Sclater, P. Nicholas, Chironis "Mechanisms and Mechanical Devices Sourcebook", New York McGraw-Hill, publications, 3rd Edition.1963

4. J. E. Shigley, R. Charles, Mischke,"Mechanical engineering and design", TMH,1st Edition, 2003.

WEB REFERENCES:

https://akanksha.iare.ac.in/index?route=course/detailscourse$_{i}d = 432$

COURSE WEB PAGE:

https://akanksha.iare.ac.in/index?route=course/detailscourse$_{i}d = 432$

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	https://lms.iare.ac.in/index?route=course/details and courseid=285
CONTENT DELIVERY (THEORY)			
1	Elements of links, classification, rigid link, flexible and fluid link	CO1	T1:1.2, R1:5.2
2	Types of kinematic pairs, sliding, turning, rolling, screw and spherical pairs	CO1	T1:1.3,1.4
3	Constrained motion, completely, Partially or successfully constrained Incompletely constrained,	CO1	T1:1.6, R1:5.6
4	mechanism and machines, Classification, kinematic chain, inversion of mechanism	CO1	T1:2.2
5	Inversion of quadratic cycle ,	CO2	T1:2.4, R1:6.2
6	Single slider crank chains,	CO2	T1:2.4, R1:6.2
7	Double slider crank chains	CO2	T1:2.4, R1:6.2
8	Instantaneous centre of rotation, centroids and axodes, relative motion between two bodies,	CO3	T1:2.8
9	Three centres in line theorem graphical determination of instantaneous centre,	CO3	T1:2.9, R1:6.8
10	Diagrams for simple mechanisms and determination of angular velocity of points and links	CO3	T1:3.2, R2:4.8
11	Velocity and acceleration, motion of link in machine	CO3	T1:3.4
12	velocity and acceleration diagrams	CO3	T1:3.5, R1:5.7
13	Relative velocity method for four bar chain	CO3	T1:3.9
14	Analysis of slider crank chain for displacement	CO3	T1:3.9, R2:4.12
15	Velocity and acceleration of sliding, acceleration diagram	CO3	T1:3.9, R2:4.12
16	Types of Belts, Material used for Belts, Types of Flat Belt Drives.	CO4	T1:7.1 T1:7.2

17	Velocity Ratio of Belt Drive, Length of an Open Belt Drive.	CO4	T1:7.5 T1:7.6
18	Power Transmitted by a Belt, Ratio of Driving Tensions for Flat Belt Drive.. Centrifugal Tension	CO4	T1:7.8, T1:7.9
19	Maximum Tension in the Belt and problems, Initial Tension in the Belt and problems	CO4	T1:7.10 T1:7.11
20	Cams and followers: Definition uses, types, terminology, types of follower motion	CO5	T1:8.1 T1:8.3, R1:7.2
21	Uniform velocity	CO5	T1:8.4, T1:8.8 R1:7.3
22	simple harmonic motion Uniform acceleration	CO5	T1:8.4, T1:8.8 R1:7.3
23	Maximum velocity and acceleration during outward and return strokes,	CO5	T1:8.9, R1:7.5
24	Gears: Types, law of gearing; Tooth profiles: Specifications, classification	CO6	T1:9.2, R1:8.2
25	Length of Path of Contact and problems	CO6	T1:9.4 R1:7.9
26	Length of Arc of Contact.	CO6	T1:9.6, R1:7.9
27	Contact Ratio, Interference in Involute Gears	CO6	T1:9.7, R2:7.8
28	Gear Trains, Simple Gear Train, Compound Gear Train..	CO4	T1:9.3
29	Reverted Gear Train. Epicyclic Gear Train.	CO4	T1:10.4, R2:7.9
30	Compound Epicyclic Gear Train (Sun and Planet Wheel).	CO4	T1:10.6
31	Compound Epicyclic Gear Train (Sun and Planet Wheel).	CO4	T1:9.5, R1:9.5
32	Compound Epicyclic Gear Train (Sun and Planet Wheel).	CO4	T1:9.6
33-34	Gyroscopes - Processional Angular Motion; Gyroscopic Couple;	CO6	T2:5.1
35	Effect of precession on the stability of airplanes	CO6	T2:5.3, R1:5.9
36	Effect of precession on the stability of ships	CO6	T2:5.4
37	Effect of precession on the stability of ships	CO6	T2:5.4
38	Effect of precession on the stability of for wheel vehicles,	CO6	T2:5.4, R2:4.9
39	Effect of precession on the stability of for wheel vehicles,	CO6	T2:5.4, R2:4.9
39	Effect of precession on the stability of motorbikes,	CO6	T2:5.7
40	Balancing of rotating masses Balancing of a Single Rotating Mass By a Single Mass Rotating in the Same Plane.	CO5	T2:21,1 R2:7.2
41	Balancing of rotating masses Balancing of a Single Rotating Mass By a Single Mass Rotating in the Same Plane.	CO5	T2:21,1 R2:7.2

42	.Balancing of a Single Rotating Mass By Two Masses Rotating in Different Planes	CO5	T2:21.2
43	Problems on Balancing of a Single Rotating Mass By Two Masses Rotating in Different Planes	CO5	T2:21.3
44	Balancing of Several Masses Rotating in the Same Plane..	CO5	T2:22.4
45	Balancing of Several Masses Rotating in Different Planes.	CO5	T2:22.5
	PROBLEM SOLVING/ CASE STUDIES		
46	Inversion of quadratic cycle	CO2	T1:2.4, R1:6.2
47	Single slider crank chains,	CO2	T1:2.6, R1:6.5
48	Graphical method: Velocity diagrams	CO3	T1:2.9, R1:6.8
49	Relative method: Velocity and acceleration diagrams	CO3	T1:3.9, R2:4.12
50	Belt Drives: Power Transmitted by a Belt,	CO4	T1:7.5 T1:7.6
51	Cams and follower: Uniform velocity, simple harmonic motion Uniform acceleration	CO5	T1:8.4, T1:8.8 R1:7.3
52	Toothed gearing: Length of Arc of Contact and contact ratio	CO6	T1:9.6, R1:7.9
53	Reverted Gear Train. Epicyclic Gear Train.	CO4	T1:10.4, R2:7.9
54	Effect of precession on the stability of airplanes and naval ships	CO6	T2:5.3, R1:5.9
55	Problems on Balancing of a Single Rotating Mass By Two Masses Rotating in Different Planes	CO5	T2:22.4
	DISCUSSION OF DEFINITION AND TERMINOLOGY		
56	MECHANISMS & MACHINES	CO1, CO2	T1:2.4, R1:6.2
57	KINEMATIC ANALYSIS OF MECHANISMS	CO3	T1:3.9, R2:4.12
58	BELT DRIVES, AND CAMS AND FOLLOWERS	CO4,CO5	T1:7.5 T1:7.6
59	GEARS AND GEAR TRAINS	CO6,CO4	T1:9.6, R1:7.9
60	GYROSCOPIC COUPLE AND PRECESSION MOTION	CO6, CO5	T2:5.3, R1:5.9 T2:22.4
	DISCUSSION OF QUESTION BANK		
61	MECHANISMS & MACHINES	CO1, CO2	T1:2.4, R1:6.2
62	KINEMATIC ANALYSIS OF MECHANISMS	CO3	T1:3.9, R2:4.12
63	BELT DRIVES, AND CAMS AND FOLLOWERS	CO4,CO5	T1:7.5, T1:7.6

64	GEARS AND GEAR TRAINS	CO6	T1:9.6, R1:7.9
65	GYROSCOPIC COUPLE AND PRECESSION MOTION	CO6	T2:5.3, R1:5.9 T2:22.4

Course Coordinator **HOD,AE**
Dr D Govardhan, 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**