PSN COLLEGE OF ENGINEERING AND TECHNOLOGY

(An Autonomous Institution Recognised by AICTE, New Delhi
and affiliated to Anna University, Chennai)
Accredited with A+ Grade by NAAC. An ISO 9001:2015 Certified Institution
Melathediyoor, Tirunelveli – 627 152

B.E. AERONAUTICAL ENGINEERING

Curriculum and Syllabus

SEMESTER I TO VI

and

VERTICAL 1 To 8

Regulation 2022

VISION AND MISSION OF THE INSTITUTE:

Institution Vision	To emerge as a pioneer institute inculcating engineering education, skills, research, values and ethics.	
Institution Mission	**IM-1**	To achieve greater heights of excellence in technical knowledge and skill development through innovative teaching and learning practices.
	IM-2	To develop the state of art infrastructure to meet the demands of technological revolution.
	IM-3	To improve and foster research in all dimensions for betterment of society.
	IM-4	To develop individual competencies to enhance innovation, employability and entrepreneurship among students.
	IM-5	To instill higher standards of discipline among students, inculcating ethical and moral values for societal harmony and peace.

VISION AND MISSION OF THE DEPARTMENT:

Department Vision	The Department of Aeronautical Engineering will strive and achieve the global recognition as a center of Excellence by imparting quality education, leading to graduates becoming professionals with specialized knowledge in Aeronautical Engineering.	
Department Mission	**DM-1**	To prepare the students to acquire good fundamental knowledge in various fields of Aeronautical Engineering, develop problem solving skills and learn application oriented concepts.
	DM-2	To prepare the students to have good social, moral and ethical values.
	DM-3	To provide conducive environment to enhance the potential for sponsored research and consultancy projects.

Program Outcomes (POs):

PO's No	KNOWLEDGE	STATEMENTS	APPLIANCE
1	Engineering Knowledge	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	Theory/ Practical / Project work
2	Problem Analysis	Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	Theory / Practical / Projects
3	Design / Development of Solutions	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	Theory / Practical / Projects
4	Conduct Investigations of Complex Problems	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	Theory / Practical
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.	Theory / Practical / Project work
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.	Theory / Industrial visit / In plant training
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.	Theory / Industrial Visit/ In plant Training

8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	Theory / Industrial visit / In plant training
9	Individual and Team Work	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	Projects
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.	Projects/ Seminar/ Mini Project
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.	Projects
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.	Projects / Higher Studies

Program Specific Outcomes [PSOs]:

PSO-1 : Graduates will be able to design and analyze various aircraft materials and structures.

PSO-2 : Graduates will be able to develop solutions for various aerodynamic, propulsion and control systems used in aircrafts.

PSO-3 Identify and apply the knowledge of aeronautical engineering for industrial applications.

CURRICULUM								
Sem - 01								
S.No	**Course Code**	**Course Name**	**Classification**		**L**	**T**	**P**	**C**
1	IC610001	Professional English I	ICC	Theory	2	0	0	2
2	IC610002	Matrices and Calculus	ICC	Theory	2	1	0	3
3	IC610003	Engineering Physics	ICC	Theory	3	0	0	3
4	IC610004	Engineering Chemistry	ICC	Theory	3	0	0	3
5	CS610005	Problem Solving and 'C' Programming	ICC	Theory	3	0	0	3
6	ME610006	Engineering Graphics with CAD	ICC	Theory with Practical Component	2	0	2	3
7	IP610101	Physics & Chemistry Laboratory	ICC	Practical	0	0	3	1.5
8	IP610102	Programming in 'C' Laboratory	ICC	Practical	0	0	3	1.5
9		NCC/NSS/NSO *	IMC	Institute Mandatory	1*	0	0	0
10	IC610007	Tamil marabu/Heritage of Tamil	ICC	Theory	1	0	0	1
		Total			**16**	**1**	**8**	**21**

Sem - 02								
11	IC620008	Professional English II	ICC	Theory with Practical Component	2	0	2	3
12	IC620009	Transforms & Partial Differential Equations	ICC	Theory	2	1	0	3
13	IC620010	Engineering Materials (for Non-Circuit Branches)	ICC	Theory	3	0	0	3
	IC620011	Semiconductor Physics (for Circuit Branches)			3	0	0	
14	ME620012	Engineering Mechanics (for Non Circuit Branches)	PCC	Theory with project	3	0	0	3
	CS620013	Fundamentals of Artificial Intelligence (for Circuit Branches)			3	0	0	
15	CS620014	Python Programming	ICC	Theory	3	0	0	3
16	ME620015	Basic Engineering	ICC	Theory	3	0	0	3

17	IP620103	Python Laboratory	ICC	Practical	0	0	3	1.5
18	IP620104	Engineering Practice laboratory	ICC	Practical	0	0	3	1.5
19	IM610401	Environmental Studies	IMC	Institute Mandatory	2*	0	0	0
20	IC620016	Tamils and Technology	ICC	Theory	1	0	0	1
		Total			**17**	**1**	**8**	**22**

Sem - 03								
21	IC630017	Numerical Methods and Statistics	ICC	Theory	3	0	0	3
22	AE630201	Aero Engineering Thermodynamics	PCC	Theory	3	0	0	3
23	ME630202	Fluid Mechanics and Machinery	PCC	Theory	3	0	0	3
24	AE630202	Solid Mechanics for Aeronautical Engineering	PCC	Theory with project	3	0	0	3
25	AE630203	Fundamentals of Aeronautics	PCC	Theory with Practical Component	2	0	2	3
26		Professional Elective-1	PEC	Theory	3	0	0	3
27	ME630301	Fluid Mechanics and Machinery Laboratory	PCC	Practical	0	0	3	1.5
28	AE630301	Solid Mechanics and Thermal Engineering Laboratory	PCC	Practical	0	0	3	1.5
29	AE630501	Integrated Aptitude Skills - I (Lower)	EEC	Skill based course	0	0	1	0.5#
30	IM630402	Universal Human Values	IMC	Theory	2*	0	0	0
		Total			**17**	**0**	**9**	**21**

Sem - 04								
31	IC640018	Boundary Value Problems and Probability distributions	ICC	Theory	3	0	0	3
32	AE640204	Aerodynamics - I	PCC	Theory with Practical Component	2	0	2	3
33	AE640205	Aircraft Structures - I	PCC	Theory with project	3	0	0	3
34	AE640206	Propulsion - I	PCC	Theory	3	0	0	3
35		Professional Elective-2	PEC	Theory	3	0	0	3
36		Institute elective -1	IEC	Theory	3	0	0	3

37	AE640302	Aerodynamics Laboratory	PCC	Practical	0	0	3	1.5
38	AE640303	Computer Aided Drafting of Aircraft Components	PCC	Practical	0	0	3	1.5
39	AE640502	Integrated Aptitude Skills - II (Lower)	EEC	skill based course	0	0	1	0.5#
40		In plant Training (2 Weeks)	IMC	-				0
		Total			**17**	**0**	**9**	**21**

Sem - 05								
41	AE650207	Propulsion - II (Rocket Propulsion)	PCC	Theory with Practical Component	2	0	2	3
42	AE650208	Aircraft Structures - II	PCC	Theory with project	3	0	0	3
43	AE650209	Aerodynamics - II	PCC	Theory	2	1	0	3
44		Institute Elective -2	IEC	Theory	3	0	0	3
45		Professional Elective-3	PEC	Theory	3	0	0	3
46		Professional Elective-4	PEC	Theory	3	0	0	3
47	AE650304	Aircraft Structures Laboratory	PCC	Practical	0	0	3	1.5
48	AE650305	Surface and Solid Modelling of Aircraft Components	PCC	Practical	0	0	3	1.5
49	AE650503	Integrated Aptitude Skills - I (Higher)	EEC	skill based course	0	0	2	1#
50	AE650801	Programme Mandatory	PMC	Theory	2*	0	0	0
		Total			**16**	**1**	**10**	**21**

Sem - 06								
51	AE660210	Aircraft Structures and Repair	PCC	Theory with Practical Component	2	0	2	3
52	AE660211	Flight Dynamics	PCC	Theory with project	3	0	0	3
53	AE660212	Finite Element Analysis	PCC	Theory	2	1	0	3
54		Institute Elective -3	IEC	Theory	3	0	0	3
55		Professional Elective-5	PEC	Theory	3	0	0	3
56		Professional Elective-6	PEC	Theory	3	0	0	3
57	AE660306	Aircraft Design Project - I	PCC	Practical	0	0	3	1.5
58	AE660307	Simulation of Aircraft Structural Components	PCC	Practical	0	0	3	1.5

59	ME660504	Training in centre for Excellence in Robotics, Sensor and PLC	EEC	Skill based course	0	0	2	1#
60	IM660403	Professional Ethics	IMC	Theory	2*	0	0	0
61		Internship	IMC					0
		Total			**16**	**1**	**10**	**21**

Sem - 07								
62	AE670213	Computational Fluid Dynamics	PCC	Theory	2	1	0	3
63	AE670214	Quality and Reliability Engineering	PCC	Theory with project	3	0	0	3
64	AE670215	Composite Materials and Structures	PCC	Theory with Practical Component	2	0	2	3
65		Institute elective -3	IEC	Theory	3	0	0	3
66		Professional elective-7	PEC	Theory	3	0	0	3
67		Professional elective-8	PEC	Theory	3	0	0	3
68	AE670308	Aircraft Design Project - II	PCC	Practical	0	0	3	1.5
69	AE670309	Computational Fluid Dynamics Laboratory	PCC	Practical	0	0	3	1.5
70	MG670019	Innovation Entrepreneurship and Start-ups	ICC	Theory	3	0	0	3
71	AE670505	Advanced Career Development	EEC	Skill based course	0	0	2	1#
		Total			**19**	**1**	**10**	**24**

Sem - 08								
72	AE680506	Project Work	EEC	Practical	0	0	20	10
SUMMARY								
SEM	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Credit	**21**	**22**	**21**	**21**	**21**	**21**	**24**	**10**
Total	**161**							

Abbreviation	Particulars
ICC	Institute core Course (includes Basic science, Engineering science, humanities & social science including management course)
PCC	Professional Core Course
PEC	Professional Elective Course
IEC	Institute Elective Course (open electives)
EEC	Employability Enhancement course
IMC	Institute Mandatory Course
PMC	Programme Mandatory Course

Vertical-1 - AERODYNAMICS AND PROPULSION

S. No.	Course Code	Course Title	Classification		L	T	P	C
1	AE606101	Aircraft Design	PEC	Theory	3	0	0	3
2	AE606102	Advanced Propulsion Systems	PEC	Theory	3	0	0	3
3	AE606103	Hypersonic Aerodynamics	PEC	Theory	3	0	0	3
4	AE606104	High Speed Aerodynamics (NPTEL)	PEC	Theory	3	0	0	3
5	AE606105	Wind Tunnel Techniques (NPTEL)	PEC	Theory	3	0	0	3
6	AE606106	Structural Dynamics (NPTEL)	PEC	Theory	3	0	0	3
7	AE606107	Aerospace Propulsion (NPTEL)	PEC	Theory	3	0	0	3
8	AE606108	Gas Dynamics and Jet Propulsion	PEC	Theory	3	0	0	3

Vertical-2 - AEROSPACE STRUCTURES

S. No.	Course Code	Course Title	Classification		L	T	P	C
1	AE606201	Fatigue and Fracture Mechanism (NPTEL)	PEC	Theory	3	0	0	3
2	AE606202	Experimental Stress Analysis (NPTEL)	PEC	Theory	3	0	0	3
3	AE606203	Aerospace Materials	PEC	Theory	3	0	0	3
4	AE606204	Additive Manufacturing (NPTEL)	PEC	Theory	3	0	0	3

5	AE606205	Non-Destructive Testing and Evaluation (NPTEL)	PEC	Theory	3	0	0	3
6	AE606206	Aerospace Manufacturing Technology	PEC	Theory	3	0	0	3
7	AE606207	Aircraft Stress Analysis	PEC	Theory	3	0	0	3
8	AE606208	Nano Materials and Aero Applications	PEC	Theory	3	0	0	3
9	AE606209	Aircraft High Temperature Materials	PEC	Theory	3	0	0	3

Vertical-3-AVIONICS AND DRONE TECHNOLOGY

S. No	Course Code	Course Title	Classification		L	T	P	C
1	AE606301	Avionics	PEC	Theory	3	0	0	3
2	AE606302	Design of UAV Systems (NPTEL)	PEC	Theory	3	0	0	3
3	AE606303	Aerodynamics of Drones	PEC	Theory	3	0	0	3
4	AE606304	Control Engineering	PEC	Theory	3	0	0	3
5	AE606305	Introduction to PLC (NPTEL)	PEC	Theory	3	0	0	3
6	AE606306	Drone Technologies	PEC	Theory	3	0	0	3
7	AE606307	Geographical Information Systems (NPTEL)	PEC	Theory	3	0	0	3
8	AE606308	Guidance and Control	PEC	Theory	3	0	0	3
9	AE606309	Navigation and Communication Systems	PEC	Theory	3	0	0	3

Vertical-4-ROCKETS AND MISSILES

S. No.	Course Code	Course Title	Classification Course Category		L	T	P	C
1	AE606401	Basics of Rockets and missiles	PEC	Theory	3	0	0	3
2	AE606402	Missile Aerodynamics	PEC	Theory	3	0	0	3
3	AE606403	Space Mechanics	PEC	Theory	3	0	0	3
4	AE606404	Cryogenics (NPTEL)	PEC	Theory	3	0	0	3
5	AE606405	Remote Sensing Concepts	PEC	Theory	3	0	0	3
6	AE606406	Missile Guidance and Control (NPTEL)	PEC	Theory	3	0	0	3
7	AE606407	Chemical Rockets	PEC	Theory	3	0	0	3
8	AE606408	Launch Vehicle Technology	PEC	Theory	3	0	0	3
9	AE606409	Combustion Theory	PEC	Theory	3	0	0	3

Vertical-5- AIRCRAFT MAINTENANCE

S. No.	Course Code	Course Title	Classification		L	T	P	C
1	AE606501	Airframe Maintenance and repair	PEC	Theory	3	0	0	3
2	AE606502	Aircraft General Engineering and Maintenance and Practices.	PEC	Theory	3	0	0	3
3	AE606503	Civil Aviation Regulations	PEC	Theory	3	0	0	3
4	AE606504	Air Traffic Control (NPTEL)	PEC	Theory	3	0	0	3
5	AE606505	Aircraft Engine Maintenance and Repair	PEC	Theory	3	0	0	3
6	AE606506	Aircraft Overhauling	PEC	Theory	3	0	0	3
7	AE606507	Sensors and Instrumentation (NPTEL)	PEC	Theory	3	0	0	3
8	AE606508	Helicopter Maintenance (NPTEL)	PEC	Theory	3	0	0	3
9	AE606509	Air Transportation and Aircraft Maintenance Engineering	PEC	Theory	3	0	0	3

Vertical-6 - AERO MANAGEMENT AND SAFETY

S. No.	Course Code	Course Title	Classification		L	T	P	C
1	AE606601	Airport Management	PEC	Theory	3	0	0	3
2	AE606602	Crisis Management in Aviation Industry	PEC	Theory	3	0	0	3
3	AE606603	Aircraft Production and Planning Management	PEC	Theory	3	0	0	3
4	AE606604	Operational Management	PEC	Theory	3	0	0	3
5	AE606605	Operation and Supply Chain Analytics	PEC	Theory	3	0	0	3
6	AE606606	Essentials of Entrepreneurship (NPTEL)	PEC	Theory	3	0	0	3
7	AE606607	Industrial Fire Safety (NPTEL)	PEC	Theory	3	0	0	3
8	AE606608	Energy Conservation and Management (NPTEL)	PEC	Theory	3	0	0	3
9	AE606609	Air Lines Operation and Scheduling	PEC	Theory	3	0	0	3

Vertical-7-DIVERSIFIED COURSES

S. No.	Course Code	Course Title	Classification		L	T	P	C
1	AE606701	Design of Gas Turbine Engine Components	PEC	Theory	3	0	0	3
2	AE606702	Vibration and aero elasticity (NPTEL)	PEC	Theory	3	0	0	3
3	AE606703	Manufacturing process	PEC	Theory	3	0	0	3
4	AE606704	Turbo Machines (NPTEL)	PEC	Theory	3	0	0	3
5	AE606705	Helicopter Theory (NPTEL)	PEC	Theory	3	0	0	3
6	AE606706	Design of Non-Air Breathing Engine	PEC	Theory	3	0	0	3
7	MA606707	Mechatronics (NPTEL)	PEC	Theory	3	0	0	3
8	AE606304	Project Management	PEC	Theory	3	0	0	3
9	AE606709	Computer Aided Design and Analysis	PEC	Theory	3	0	0	3

Vertical-8- DIVERSIFIED COURSES

S. No.	Course Code	Course Title	Classification	Course Category	L	T	P	C
1	AE606801	Boundary Layer Theory (NPTEL)	PEC	Theory	3	0	0	3
2	AE606802	Aero Elasticity	PEC	Theory	3	0	0	3
3	AE606803	Heat Transfer (NPTEL)	PEC	Theory	3	0	0	3
4	AE606804	Grid Generation Techniques	PEC	Theory	3	0	0	3
5	AE606805	Advanced Vehicle Engineering	PEC	Theory	3	0	0	3
6	AE606806	Post Processing in Drone Surveying	PEC	Theory	3	0	0	3
7	AE606807	Flexible Manufacturing Systems (Common to MAE, Mech and Aero)	PEC	Theory	3	0	0	3
8	MA606203	Aircraft Systems and Instruments	PEC	Theory	3	0	0	3
9	AE606808	MEMS (NPTEL)	PEC	Theory	3	0	0	3

SEMESTER - 3

AE630201 - AERO ENGINEERING THERMODYNAMICS						
Course Category: SEM 03	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- Aero Engineering Thermodynamics study includes quantitative analysis of machine and processes for transformation of energy and between work and heat.
- Laws of thermodynamics would be able to quantify through measurement of related properties, to these energies and their interactions.
- To develop basic concept of air cycle, gas turbine engines and heat transfer

UNIT 1: FUNDAMENTAL CONCEPT AND FIRST LAW	**9**

Concept of continuum, macroscopic approach, thermodynamic systems – closed, open and isolated. Property, state, path and process, quasi-static process, work, internal energy, enthalpy, specific heat capacities and heat transfer, SFEE, application of SFEE to jet engine components, First law of thermodynamics, relation between pressure, volume and temperature for various processes, Zeroth law of thermodynamics

UNIT 2: SECOND LAW AND ENTROPY	**9**

Second law of thermodynamics – Kelvin Planck and Clausius statements of second law. Reversibility and Irreversibility, Thermal reservoir, Carnot theorem. Carnot cycle, Reversed Carnot cycle, efficiency, COP, Thermodynamic temperature scale - Clausius inequality, Concept of entropy, Entropy change for various processes. Mixing of fluids.

UNIT 3: AIR STANDARD CYCLES	**9**

Otto, Diesel, Dual, Ericsson, Atkinson, Stirling and Brayton cycles - air standard efficiency –mean effective pressure

UNIT 4: FUNDAMENTALS OF VAPOUR POWER CYCLES	**9**

Properties of pure substances – solid, liquid and vapour phases, phase rule, p-v, p-T, T-v, T-s, h-s diagrams, p-v-T surfaces, thermodynamic properties of steam - calculations of work done and heat transfer in non-flow and flow processes - standard Rankine cycle, Reheat and Regeneration cycle. Heat rate, Specific steam consumption, Tonne of refrigeration.

UNIT 5: BASICS OF PROPULSION AND HEAT TRANSFER	**9**

Classification of jet engines - basic jet propulsion arrangement – Engine station number, thrust equation – Specific thrust, SFC, TSFC, specific impulse, actual cycles, isentropic efficiencies of jet engine components, polytropic efficiency, conduction in parallel, radial and composite wall, basics of convective and radiation heat transfer.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to
CO1: Able to relate laws of thermodynamics to jet engine components.
CO2:Analysis principle operation of piston engine and jet engines.
CO3: Able to identify efficient cycle of air and jet engines.
CO4: Capable to illustrate condition of working medium.
CO5: Eligible to recognize and calculate heat transfer in complex systems involving several heat transfer mechanisms.

CO'S PO'S&PSO'S MAPPING

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	3	2	2	3	-	-	-	-	1	-	1	-	3	3
CO2	3	2	2	2	1	-	-	-	-	1	-	1	-	3	2
CO3	2	3	2	3	2	1	1	-	-	-	1	2	2	2	1
CO4	2	2	2	3	2	1	1		-	-	1	2	2	1	1
CO5	3	2	3	3	3	1	-1		1	1	2	2	2	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Nag.P.K., "Engineering Thermodynamics", Tata McGraw-Hill, New Delhi, 2013.

2. Rathakrishnan E., "Fundamentals of Engineering Thermodynamics", Prentice-Hall India, 2005.

3. Yunus A. Cengel and Michael A. Boles, "Thermodynamics: An Engineering Approach" McGraw-Hill Science/Engineering/Math; 7thedition 2010

REFERENCE BOOKS:

1. Arora C.P, " Thermodynamics", Tata McGraw-Hill, New Delhi, 2003.

2. Holman.J.P., "Thermodynamics", 3rd Edition, McGraw-Hill, 2007.

3. Merala C, Pother, Craig W, Somerton, "Thermodynamics for Engineers", Schaum Outline Series,Tata McGraw-Hill, New Delhi, 2004.

WEB RESOURCES:

1. Introduction to boundary layers: https://nptel.ac.in/courses/112106190

ME630202 - FLUID MECHANICS AND MACHINERY						
Course Category: SEM 03	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To introduce to the mechanics of fluids through a thorough understanding of the properties of the fluids.
- To familiarized the students with conservation laws and dimensional analysis to fluid and flow problems.
- To analysis and obtain knowledge the concept of flow through pipes.
- To gain knowledge in the turbine and also various types of turbines and performance curve characteristics are to be studied.
- To analysis functioning and operation of hydraulic pumps.

UNIT 1:FLUID PROPERTIES & CHARACTERISTICS	**9**

Basic Concept and fluid Properties - Density – Specific Weight – Specific Gravity – viscosity – surface tension – capillary rise –compressibility - Hydrostatic Law – Pressure Variation in static fluid – Hydrostatic force on a submerged plane surfaces – Location of hydrostatic force - Manometers – Simple U tube and differential manometers – Buoyancy – Meta-centric height – determination of stability of floating bodies and submerged bodies.

UNIT 2: EQUATIONS OF MOTION AND DIMENSIONAL ANALYSIS	**9**

Basic Equations of Motion - Types of fluid flow – Continuity Equation, momentum and energy equations – Euler's and Bernoulli's Equation and its applications - Orifice meter - Venturi meter - Pitot tube. Dimensional Analysis - Buckingham's ∏ Theorem – Non dimensional numbers – Similitude - Model studies.

UNIT 3: FLOW THROUGH PIPES	**9**

Laminar and Turbulent flow - Reynolds experiment – Major and minor losses in pipes – Darcy weisbach's equation and Chezy's formula – Pipes in series, parallel and branched – Total energy line – Hydraulic gradient line – Equivalent pipe.

UNIT 4:HYDRAULIC TURBINES	**9**

Classification of hydraulic turbines – Working principle of Pelton wheel, Francis and Kaplan turbines – Velocity triangles – Work done – Specific Speed – Performance Curve for turbine -Draft tube – Hydraulic turbine characteristics.

UNIT 5: HYDRAULIC PUMPS	9
Centrifugal Pumps - Definition – Operations – Velocity Triangles – Performance curves – Cavitations – Multi staging. Reciprocating Pumps - Operation – Slip – indicator Diagram – Separation – Air vessels, and performance curve, Cavitations in pumps Rotary pumps Working Principles of gear and vane pumps.	
TOTAL: 45 PERIODS	

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Analysis the basic fluid mechanics through the properties of various fluids.

CO2: Ability to analyse the fluid flow problems with the applications of momentum and energy equations.

CO3: Analysis and apply knowledge in the flow concepts through pipes.

CO4: Analysis the types of turbines and also the characteristics of turbine has been studied.

CO5: Analysis the basic function and operation of pumps and performance curves has been studied.

CO'S PO'S&PSO'S MAPPING

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	2	2	2	1	-	-	-	-	-	-	1	2	-	-
CO2	3	3	2	1	1	-	-	-	-	-	-	2	1	-	-
CO3	2	1	2	2	1	-	-	-	-	-	-	2	2	1	1
CO4	2	1	2	2	2	-	-	-	-	-	-	1	2	-	1
CO5	3	2	3	3	1	-	-	-	-	-	-	1	2	1	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. R. K. Bansal. "Fluid Mechanics & Hydraulics Machines", 9th Edition, Laxmi Publications, 2010.

2. BModi P. N., Seth S. M., "Hydraulics and Fluid Mechanics", Standard Book House, 2011..

3.Govinda Rao N. S., "Fluid Flow Machines", 2nd Edition, Tata McGraw Hill, New Delhi, 1990, Digitized 2008.

REFERENCE BOOKS:

1. Kumar K. L., "Engineering Fluid Mechanics", 8th Edition, Eurasia Publication, 2010.

2.Streeter V.L. and Wylie E.B., "Fluid Mechanics ", McGraw Hill, 1983.

3. Ramamirtham S., "Fluid Mechanics, Hydraulics and Fluid Machines ", DhanpatRai& Sons, Delhi, 1988.

4. Douglas. J. F., Gasiorek.J.M. ,Swaffield.J.A., "Fluid Mechanics ELBS", 4th Edition, Prentice Hall, 2000.

WEB RESOURCES:

1. Theory of Elasticity: https://nptel.ac.in/courses/105105177

AE630202- SOLID MECHANICS FOR AERONAUTICAL ENGINEERING						
Course Category: SEM 03	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To gain knowledge of simple stresses, strains and deformation in components due to external loads.
- To assess stresses and deformations through mathematical models of beams, twisting bars or combinations of both.
- To analysis the effect of component dimensions and shape on stresses and deformations.
- To evaluate the torsion in the shaft and spring
- To analyse the strength of column and thin cylinder

UNIT 1: SIMPLE STRESS AND STRAIN	**9**

Rigid and Deformable bodies – Stresses; Tensile, Compressive and Shear – stresses in simple and compound bars under axial load - Elastic constants and it's relations - Thermal stress – Principle stress and strain due to combination of stresses – Mohr's circle.

UNIT 2: STRESSES IN BEAMS	**9**

Types of beams: Supports and Loads – Shear force and Bending Moment in beams –Cantilever, Simply supported and Overhanging beams – Stresses in beams – Theory of simple bending – Stress variation along the length and in the beam section – Effect of shape of beam section on stress induced – Shear stresses in beams – Shear flow.

UNIT 3: DEFLECTION OF BEAMS	**9**

Elastic curve of Neutral axis of the beam under normal loads – Evaluation of beam deflection and slope: Double integration method, Macaulay Method, and Moment-area Method.

UNIT 4: TORSION & SPRINGS	**9**

Stresses and strains in pure torsion of solid circular shafts and hollow circular shafts - Power transmitted by shafts subjected to combination of bending and torsion. Open and closely coiled springs under torque and moment – Laminated Spring.

UNIT 5: COLUMNS, THIN CYLINDERS AND SPHERES	**9**

Columns – End conditions – Equivalent length of a column – Euler equation –Slenderness ratio – Rankine formula for columns - Thin Cylinders and Spheres - Derivation of formulae and calculations of hoop

stress, longitudinal stress in a cylinder, and sphere subjected to internal pressures.
TOTAL: 45 PERIODS
COURSE OUTCOMES: At the end of the course, the student will be able to
CO1: Understand the concepts of stress and strain in simple and compound bars, the importance of principal stresses and principal planes.
CO2: Understand the load transferring mechanism in beams and stress distribution due to shearing force and bending moment.
CO3: Apply basic equation of simple torsion in designing of shafts and helical spring
CO4: Calculate the slope and deflection in beams using different methods.
CO5: Analyze and design thin and thick shells for the applied internal and external pressures.

CO'S PO'S&PSO'S MAPPING

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	2	2	1	1	-	-	-	-	-	-	1	2	-	-
CO2	2	2	2	1	1	-	-	-	-	-	-	1	-	2	1
CO3	2	2	3	-3	1	-	-	-	-	-	-	2	2	-	-
CO4	2	2	2	3	1	-	-	-	-	-	-	2	-	-	-
CO5	2	3	2	3	-1	-	-	-	-	-	-	2	-	-	

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Beer P F and Johson (Jr) E R, *"Mechanics of Materials",* SI Version, McGraw Hill, NY

2. Bhavikatti. S, "Solid Mechanics", Vikas Publishing House Pvt. Ltd., New Delhi, 2013.

3. Popov Eger P., "Engineering Mechanics of solids", Prentice Hall, New Delhi, 1998.

REFERENCE BOOKS:

1. Jindal U.C., "Strength of Materials", Galgotia Publication, New Delhi, II Edition, 2008.

2. Sadhu Singh, "Strength of Materials", Khanna Publishers, New Delhi, 2000.

3.Pytel A H and Singer F L, *"Strength of Materials",* Harper Collins, New Delhi.

WEB RESOURCES:

1.Aeroelasticity - https://nptel.ac.in/courses/101104005

AE630203 - FUNDAMENTALS OF AERONAUTICS					
Course Category: SEM 03	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To analysis the Historical evaluation of Airplanes
- To study the different component systems and functions
- To analysis basic properties and principles behind the flight
- To evaluate the different structures & construction
- To impart knowledge about the various types of power plants used in aircrafts

UNIT 1: AIRCRAFT CONFIGURATIONS	**9**

Brief History - Different types of flight vehicles, classifications. Components of an airplane and their functions. Conventional control, Powered control, Basic instruments for flying, typical systems for control actuation.

UNIT 2: INTRODUCTION TO PRINCIPLES OF FLIGHT	**9**

Physical properties and structure of the atmosphere, Temperature, pressure and altitude relationships, Newtons law of motion, Evolution of lift, drag and moment, maneuvers, Different types of drag.

UNIT 3: AERODYNAMICS	**9**

Aerodynamic forces on aircraft – aerofoil characteristics - aspect ratio, wing loading, Mach number-centre of pressure and aerodynamic centre - lift, drag curves.

UNIT 4: AIRPLANE STRUCTURES AND MATERIALS	**9**

Aircraft structures - Loads - General types of construction, Monocoque, semi-monocoque, geodesic constructions Typical wing and fuselage structure. Metallic and non-metallic materials, Use of aluminum alloy, titanium, stainless steel and composite materials.stresses and strains –stress strain diagrams ,Factor of safety

UNIT 5: POWER PLANTS USED	**9**

Basic ideas about piston, turboprop and jet engines, Use of propeller and jets for thrust production., comparative merits , Principles of operation of rocket, types of rockets and applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Ability to identify the types & classifications of components and control systems.

CO2: Analysis basic concepts of flight & Physical properties of Atmosphere.

CO3: Ability to understand the basic aerodynamics and airfoil characteristics.

CO4: An ability to differentiate the types of fuselage and constructions.

CO5: Different types of Engines and principles of Rocket operations.

CO'S PO'S&PSO'S MAPPING

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	1	1	1	1	-	-	-	-	-	-	1	2	-	-
CO2	3	2	2	2	2	-	-	-	-	-	-	1	-	-	-
CO3	3	2	2	1	1	-	-	-	-	-	-	2	2	2	1
CO4	3	2	1	1	1	-	-	-	-	-	-	2	2	-	1
CO5	2	1	1	1	1	-	-	-	-	-	-	2	2	2	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Anderson, J.D., Introduction to Flight, McGraw-Hill; 8th edition , 2015.

2. Stephen.A. Brandt, Introduction to aeronautics: A design perspective, 2nd edition, AIAA Education Series, 2004.

REFERENCE BOOKS:

1.Kermode, A.C. Flight without Formulae, Pearson Education; Eleventh edition, 2011

2. Kermode, A.C., "Mechanics of flight", Himalayan Book,I edition 1997

WEB RESOURCES:

1. Heat Transfer: https://nptel.ac.in/courses/103105140

FLUID MECHANICS AND MACHINERY LABORATORY					
Course Category: Program Core	**Course Type: Practical**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**1.5**

COURSE OBJECTIVES:

- To study the flow measurement and the performance of fluid machinery by performing practical experiments in laboratory.

LIST OF EXPERIMENTS

1. Calibration of venturimeter
2. Pressure measurement with pitot static tube
3. Determination of pipe flow losses.
4. Verification of Bernoulli's theorem
5. Flow visualization by Heleshaw apparatus
6. Performance test on centrifugal pumps
7. Performance test on reciprocating pumps
8. Performance test on pelton wheel turbine.
9. Performance test on Francis turbine.
10. Determination of Viscosity of a Fluid.

TOTAL: 45 PERIODS

List of Requirements:

S.NO.	DESCRIPTION OF EQUIPMENT	QUANTITY
1.	Venturimeter set up	01
2.	Pipe friction setup	01
3.	Pitot tube setup	01
4.	Jet pump	01
5.	Submersible pump	01
6.	Centrifugal pump	01
7.	Reciprocating pump	01
8.	Pelton wheel turbine and francis turbine	01
9.	Viscosity meter	01
10.	Hele-shaw apparatus	01

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Explain and apply the basic principles of pitot static tube

CO2: Determine discharge characteristics of flow meters.

CO3: Analysis of flow visualisation

CO4Analysis the concept and operation of turbines

CO5: Able to understand the viscous flow of fluids

TEXT BOOKS:

1.R. K. Bansal. "Fluid Mechanics & Hydraulics Machines", 9th Edition, Laxmi Publications, 2010.

2. BModi P. N., Seth S. M., "Hydraulics and Fluid Mechanics", Standard Book House, 2011..

3.Govinda Rao N. S., "Fluid Flow Machines", 2nd Edition, Tata McGraw Hill, New Delhi, 1990, Digitized 2008.

REFERENCE BOOKS:

1. Kumar K. L., "Engineering Fluid Mechanics", 8th Edition, Eurasia Publication, 2010.

2. Streeter V.L. and Wylie E.B., "Fluid Mechanics ", McGraw Hill, 1983.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	-	1	-	1	-	-	2	1	1
CO2	3	3	3	2	2	-	1	-	1	-	-	2	1	1
CO3	3	2	1	2	1	-	1	-	1	-	-	2	1	1
CO4	3	1	1	1	1	-	1	-	1	-	-	2	1	1
CO5	3	1	2	2	1	-	1	-	1	-	-	2	1	1

1- low, 2 - medium, 3 - high, '-' no correlation

AE630301 - SOLID MECHANICS AND THERMAL ENGINEERING LABORATORY					
Course Category: Program Core	**Course Type: Practical**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**1.5**

COURSE OBJECTIVES:

- To develop the knowledge in testing the materials for hardness, fatigue, impact, tension and torsion
- To enhance the basic knowledge and ideas in applied thermodynamics.

LIST OF EXPERIMENTS

1.Brinell Hardness test.

2.Stress(Tension) strain characteristics and determination of young's modulus of different materials .

3. Torsion test.

4. Testing of springs.

5.Determination of effectiveness of a parallel flow &counter flow heat exchanger.

6. Performance test on a 4-stroke engine.

7. COP of a vapour compression refrigeration rig.

8. COP of a vapour compression air-conditioning rig.

9.Determination of Thermal Conductivity of solid.

10. Determination of Thermal Resistance of a Composite wall.

TOTAL: 45 PERIODS

List of Requirements:

S.NO.	DESCRIPTION OF EQUIPMENT	QUANTITY
11.	Hardness Testing Machine	01
12.	Universal Testing Machine	01
13.	Torsion Test Machine	01
14.	Spring Testing Machine	01
15.	Four stroke twin cylinder Diesel Engine	01
16.	Parallel and Counter flow heat exchanger test rig	01
17.	Vapour compression refrigeration test rig	01
18.	Vapour compression airconditioning test rig	01
19.	Conductive heat transfer setup	01
20.	Composite wall	01

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Test and quantify the mechanical properties of Engineering Materials.

CO2: Acquire knowledge on bending properties of beams.

CO3: Estimate the performance of heat exchangers

CO4: Apply principles of convective heat transfer characteristics to practical systems.

CO5: Acquire Knowledge on ignition aspects of fuels and thermal properties of fuels

TEXT BOOKS:

1. Beer P F and Johson (Jr) E R, *"Mechanics of Materials",* SI Version, McGraw Hill, NY

2. Bavikatti. S, "Solid Mechanics", Vikas Publishing House Pvt. Ltd., New Delhi, 2013.

3. Holman.J.P., "Thermodynamics", 3rd Edition, McGraw-Hill, 2007.

REFERENCE BOOKS:

1. Jindal U.C., "Strength of Materials", Galgotia Publication, New Delhi, II Edition, 2008.

2. Rathakrishnan E., "Fundamentals of Engineering Thermodynamics", Prentice-Hall India, 2005.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	2	1	1	1	-	1	-	-	2	1	1
CO2	3	2	3	2	2	1	1	-	1	-	1	2	1	1
CO3	3	2	1	2	1	1	1	-	1	-	1	2	1	1
CO4	3	1	3	1	1	1	1	-	1	-	1	2	1	1
CO5	3	1	1	1	1	1	1	-	1	-	-	2	1	1

1- low, 2 - medium, 3 - high, '-' no correlation

SEMESTER - 4

AE640204 - AERODYNAMICS - I						
Course Category: SEM 04	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

- To introduce the concepts of mass, momentum and energy conservation relating to aerodynamics.
- To make the student understand the concept of vorticity, irrotationality, theory of airfoils and wing sections.
- To introduce the basics of viscous flow.

UNIT 1 INTRODUCTION TO LOW-SPEED FLOW	**9**
Continuity, Momentum, energy equations, incompressible Bernoulli's equation. Circulation and vortices, Kelvin's theorem, streamline, stream function, irrotational flow, potential function, equipotential lines,	
UNIT 2 TWO DIMENSIONAL INVISCID INCOMPRESSIBLE FLOW	**9**
Elementary flows and their combinations, Ideal Flow over a circular cylinder, D'Alembert's paradox, Magnus effect, Kuttajoukowski's theorem, starting vortex, kutta condition, real flow over smooth and rough cylinder.	
UNIT 3 AIRFOIL THEORY	**9**
Cauchy-Riemann relations, complex potential, methodology of conformal transformation, KuttaJoukowski transformation and its applications, Karmann-Trefftz profiles, thin airfoil theory and its applications.	
UNIT 4 SUBSONIC WING THEORY	**9**
Vortex filament, biot and savart law, bound vortex and trailing vortex, horse shoe vortex, Prandtl's lifting line theory and its limitations.	
UNIT 5:INTRODUCTION TO BOUNDARY LAYER THEORY	**9**
Boundary layer and boundary layer thickness, displacement thickness, momentum thickness, energy thickness, boundary layer equations for a steady, two dimensional incompressible flow, boundary layer growth over a flat plate, critical Reynolds number, blasius solution, basics of turbulent flow.	
	TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: ability to understand the basic understanding of low speed flow.

CO2: ability to gain knowledge incompressible flow.

CO3: ability to apply airfoil theory to predict airfoil performance.
CO4: Ability to understand the subsonic wing theory.
CO5: Illustration about the explosive to boundary layer theory.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O 1	PS O 2	PS O 3
CO1	3	3	2	2	2	-	-	-	-	-	-	3	-	3	3
CO2	3	3	2	2	2	-	-	-	-	-	-	3	-	3	2
CO3	3	2	2	3	2	-	-	-	-	-	-	3	2	2	1
CO4	3	2	2	2	2	-	-	-	-	-	-	3	2	1	1
CO5	3	3	2	1	3	-	-	-	-	-	-	3	2	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS

1. Anderson, J.D., "Fundamentals of Aerodynamics", McGraw Hill Book Co. Fifth edition2011

2. E. RathaKrishnan "Theoretical Aerodynamics" Wiley First edition 2013.

3. Houghton, E.L., and Caruthers, N.B., "Aerodynamics for Engineering students", Edward Arnold publishers ltd., London, 1989**.**

REFERENCE BOOKS:

1. Clancy, L J.," Aerodynamics", Pitman, Company Second edition 1986.

2. Milne, L.H., Thomson, Theoretical Aerodynamics, Dover Publishing company Second edition 1985.

WEB RESOURCES:

1. Introduction to boundary layers: https://nptel.ac.in/courses/112106190

ME640205 - Aircraft Structures - I					
Course Category: SEM 04	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To study different types of truss subjected to various types of loading and composite beams.
- To learn the analysis of propped cantilever and fixed beams.
- To learn the concepts of energy methods

• To understand the beam and column stress. • To learn apply aircraft structural problems using failure theory.	
UNIT 1: STATICALLY DETERMINATE STRUCTURES	**9**
Analysis of plane Truss - Method of joints – methods of sections-methods of shear- 3 D Truss - Plane frames- Composite beam.	
UNIT 2: STATICALLY INDETERMINATE STRUCTURES	**9**
Propped Cantilever - Fixed-Fixed beams- Clapeyron's Three Moment Equation – Moment Distribution Method..	
UNIT 3: ENERGY METHODS	**9**
Strain Energy in axial, bending and Torsional loads, shear loading – Castigliano's theorems- Maxwell's Reciprocal theorem, Unit load method - application to beams,frames, rings and trusses.	
UNIT 4: COLUMNS	**9**
Columns with various end conditions – Euler's Column curve – Rankine's formula - Column with initial curvature - Eccentric loading – South well plot – Beam column-Beam column with different end conditions-stresses in beam columns.	
UNIT 5: FAILURE THEORY	**9**
Maximum Stress theory – Maximum Strain Theory – Maximum Shear Stress Theory – Distortion Theory – Maximum stress energy theory -Maximum Strain energy theory – Application to aircraft Structural problems-Octahedral shear stress theory	
	TOTAL: 45 PERIODS
COURSE OUTCOMES: At the end of the course, the student will be able t	
CO1: Ability to perform linear static analysis of determinate and indeterminate aircraft structural components	
CO2: Calculate the response of statically indeterminate structures under various loading conditions.	
CO3: Calculate the reactions of structures using strain energy concept.	
CO4: Create a structure to carry the given load.	
CO5: Examine the structural failures using failure theories	

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	3	3	3	2	-	-	-	1	-	-	3	2	-	-
CO2	3	2	3	2	2	-	-	-	-	-	-	3	1	-	-
CO3	3	2	2	3	3	-	-	-	1	-	-	3	2	1	1
CO4	3	2	3	3	2	-	-	-	-	-	-	3	2	-	1
CO5	3	2	2	3	2	-	-	-	-	-	-	3	2	1	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Megson T M G, "Aircraft Structures for Engineering students" Elsevier Science and Technology, 2007

2. Timoshenko and Gere, "Mechanics of Materials", CBS publisher second edition 2006.

REFERENCE BOOKS:

1. Donaldson, B.K., "Analysis of Aircraft Structures - An Introduction", Cambridge university press II edition 2008.

2. Bruhn.E.F, "Analysis and Design of Flight Vehicle Structures", Tri-State Off-set Company,USA,Third edition 2006.

WEB RESOURCES:

1. Theory of Elasticity: https://nptel.ac.in/courses/105105177

AE640206- PROPULSION – I

Course Category: SEM 04	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To introduce basic concepts of jet propelled engines which are operated in atmosphere to students.
- To obtain knowledge in gas turbine engine.
- To obtain knowledge in subsonic and supersonic inlets for jet engine
- To obtain knowledge in the concepts of combustion chambers, nozzles and compressors for jet engine
- To understand the concept of nozzle and their importance in jet engine.
- To understand the concept of compressor.

UNIT 1: FUNDAMENTALS OF GAS TURBINE ENGINES **9**

Illustration of working of gas turbine engine – The thrust equation – Factors affecting thrust – Effect of pressure, velocity and temperature changes of air entering compressor – Methods of thrust augmentation –

Characteristics of turboprop, turbofan and turbojet – Performance characteristics.	
UNIT 2: SUBSONIC AND SUPERSONIC INLETS FOR JET ENGINES	**9**
Internal flow and Stall in subsonic inlets – Boundary layer separation – Major features of external flow near a subsonic inlet – Relation between minimum area ratio and eternal deceleration ratio – Diffuser performance – Supersonic inlets – Starting problem on supersonic inlets – Shock swallowing by area variation – External declaration – Modes of inlet operation.	
UNIT 3: COMBUSTION CHAMBERS	**9**
Classification of combustion chambers – Important factors affecting combustion chamber design – Combustion process – Combustion chamber performance – Effect of operating variables on performance – Flame tube cooling – Flame stabilization – Use of flame holders – Numerical problems.	
UNIT 4: NOZZLES	**9**
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.	
UNIT 5: COMPRESSORS	**9**
Principle of operation of centrifugal compressor – Work done and pressure rise – Velocity diagrams – Diffuser vane design considerations – Concept of pre whirl, rotation stall and surge – Elementary theory of axial flow compressor – Velocity triangles – degree of reaction – Three dimensional – Air angle distributions for free vortex and constant reaction designs – Compressor blade design – Centrifugal and Axial compressor performance characteristics.	
	TOTAL: 45 PERIODS
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: To analysis the basic concepts of gas turbine engines.	
CO2: To analysis and gained knowledge in the subsonic and supersonic inlets for jet engine systems.	
CO3: To analysis the classification of combustion chambers and flame cooling methods.	
CO4: To analysis the nozzle theory and thrust reversal concept.	
CO5:To analysis the principle of compressor and types of compressor performance characteristics	
CO'S PO'S&PSO'S MAPPING	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	2	-	3	-	-	-	-	-	-	-	-	2	2	-	-
CO2	-	3	-	2	-	-	-	-	2	-	-	-	-	2	1
CO3	2	-	3	-	-	-	-	-	-	-	-	2	2	-	-
CO4	2	-	-	2	3	-	-	-	-	-	-	-	-	-	-
CO5	-	3	-	-	-	-	-	-	-	-	-	-	-	-	

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.Hill, P.G. & Peterson, C.R. "Mechanics & Thermodynamics of Propulsion" Second Edition Dorling Kindersley India 2009.

2. Mathur, M.L. and Sharma, R.P., "Gas Turbine, Jet and Rocket Propulsion", Standard Publishers & Distributors, Delhi, 2014..

3.Rolls Royce, "Jet Engine", 5th Edition, Rolls Royce Technical Publications, 2005.. Fung, Y.C. An Introduction to the theory of Aeroelasticity, Dover Publications Inc., 2008.

REFERENCE BOOKS:

1. Blevins R.D, "Flow induced vibrations", Krieger Pub Co; 2 Reprint editions, 2001.1. Cohen, H. Rogers, G.F.C. and Saravanamuttoo, H.I.H. "Gas Turbine Theory", Pearson education Limited, Sixth Edition 2009.

2. Oates, G.C., "Aero thermodynamics of Aircraft Engine Components", AIAA Education Series, New York, Third edition 2009.

3. Bill Gunston "The development of Jet and Turbine Aero Engines" Haynes Publishing U.K Fourth Edition,2006

WEB RESOURCES:

1.Aeroelasticity - https://nptel.ac.in/courses/101104005

AE640302 - AERODYNAMICS LABORATORY					
Course Category: Program Core	**Course Type: Practical**	**L**	**T**	**P**	**C**
		0	**0**	**4**	**2**

COURSE OBJECTIVES:

To familiarize the students in basic aerodynamics and use of wind tunnels.

LIST OF EXPERIMENTS

1. Calibration of subsonic wind tunnel.
2. Flow visualization for different models in water flow channel.
3. Pressure distribution over smooth circular cylinder.
4. Pressure distribution over symmetric airfoil and estimation of C L and CD.
5. Pressure distribution over cambered airfoil and estimation of C L and CD.
6. Pressure distribution over rough circular cylinder and estimation of C L and CD.
7. Study experiment of flow over different models using Heleshaw apparatus.
8. Calculation of Cl and Cd using force balance system.
9. Tuft Visualisation.

TOTAL: 45 PERIODS

List of Requirements:

S.NO.	DESCRIPTION OF EQUIPMENT	QUANTITY
1	Water flow channel & models	1
2.	Subsonic wind tunnel	1 set
3.	Manometer, Pitot static tube	1
4.	Rough and smooth circular cylinder	1 each
5.	Airfoil pressure distribution models	1 each

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Ability to use the fundamental dynamic principles in aircraft applications.

CO2: Describe the fundamental aerodynamic and geometrical properties related to external flows over airfoils, wings, and bluff bodies

CO3: Use thin aerofoil theory to evaluate the performance of thin airfoils and the effects of angle of attack and camber.

CO4: Able to understand the aspect flow patterns.

CO5: Estimate the various forces and moments acting on aerodynamic bodies.

TEXT BOOKS:

1. Anderson, J.D., "Fundamentals of Aerodynamics", McGraw Hill Book Co. Fifth edition2011

2. E. RathaKrishnan “Theoretical Aerodynamics” Wiley First edition 2013.

3. Houghton, E.L., and Caruthers, N.B., "Aerodynamics for Engineering students", EDWARD ARNOLD PUBLISHERS LTD., LONDON, 1989**.**

REFERENCE BOOKS:

1. Clancy, L J.," Aerodynamics", Pitman, Company Second edition 1986.

2. Milne, L.H., Thomson, Theoretical Aerodynamics, Dover Publishing company Second edition 1985.

CO’S PO’S&PSO’S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	3	3	3	2	2	2	3	1	2	2	1	1
CO2	3	2	3	2	2	3	2	1	2	2	2	2	1	1
CO3	3	2	3	2	3	2	2	1	2	2	2	2	1	1
CO4	3	2	3	2	3	2	2	1	2	2	2	2	1	1
CO5	3	2	3	2	2	2	2	2	2	2	2	2	1	1

1- low, 2 - medium, 3 - high, ‘-' no correlation

AE640303 - COMPUTER AIDED DRAFTING OF AIRCRAFT COMPONENTS					
Course Category: Program Core	**Course Type: Practical**	**L**	**T**	**P**	**C**
		0	**0**	**4**	**2**

COURSE OBJECTIVES:

To familiarize the students in basic aerodynamics and use of wind tunnels.

- To make the students familiarize with computational fluid dynamics and structural analysis software tools.
- To learn the concepts involved in designing a product
- To analysis the importance of specification paraments while designing

LIST OF EXPERIMENTS

1. Computer aided design of subsonic diffusers.
2. Computer aided design of supersonic diffusers
3. Computer aided design of a compressor blade.
4. Computer aided design of convergent nozzle

5. Computer aided design of a Converging-diverging nozzle.

6. Computer aided design of typical aircraft wing.

7. Computer aided design of typical fuselage structure.

8. Computer aided design of a landing gear.

9. Computer aided design of a launch vehicles.

10. Computer aided design of a re-entry vehicles.

11. Computer aided design of a Missiles.

12. Computer aided design of a Satellites.

TOTAL: 45 PERIODS

List of Requirements:

S.NO.	DESCRIPTION OF EQUIPMENT	QUANTITY
1	Desk top computers	30

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Compare commercial design software and understand its structure.

CO2: Deduct the aircraft and spacecraft components and solve engineering problems.

CO3: Explain a formal technical report and convey engineering specifications.

TEXT BOOKS:

1. Anderson, J.D., "Fundamentals of Aerodynamics", McGraw Hill Book Co. Fifth edition20111. Chairs Mcmahon and Jimmie Browne, "CAD / CAM: Principles, Practice and Manufacturing Management", Prentice Hall, 2nd Ed., 1999.

2. Ibrahim Zoid., "CAD / CAM", Theory and Practice, TMH, 2001.

3. Radhakrishnan, P., "CAD / CAM / CIM", New Age International, 2000.

REFERENCE BOOKS:

1. Chandupatla and Bolagundu., "Introduction to Finite Element Methods in Engineering", Pearson Education India, 4th Ed., 2015.

2 Mikell P. Groover, "CAD/CAM: Computer-Aided Design and Manufacturing", PHI, 2003.

3. Newman and Sproull, R.F., "Principles of interactive Computer Graphics", TMH, 1997.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	2	2	1	3	2	2	-	-	-	-	2	2	1
CO2	2	2	2	-	2	3	2	-	-	-	-	2	2	1
CO3	3	3	3	1	3	2	1	1	-	1	-	1	2	1
CO4	1	2	3	2	3	2	2	1	2	2	2	2	1	1
CO5	3	2	3	2	2	2	2	2	2	2	2	2	1	1

1- low, 2 - medium, 3 - high, '-' no correlation

SEMESTER - 5

AE650207 - PROPULSION - II (ROCKET PROPULSION)		
Course Category: Professional Core	**Course Type: Theory with Practical Component**	**L T P C** **2 0 2 3**
COURSE OBJECTIVES:		

•To impart knowledge about non-air-breathing and hypersonic propulsion methods.

•To gain knowledge about chemical Rocket Propulsion.

•To evaluate the solid rocket propulsion fundamentals.

•To impart knowledge on Liquid and Hybrid Rocket Propulsion

•To impart knowledge on Advanced Propulsion Systems

Unit 1: Hypersonic Air Breathing Propulsion **9**

Introduction to hypersonic air breathing propulsion, hypersonic vehicles and supersonic combustion-need for supersonic combustion for hypersonic propulsion – salient features of scramjet engine and its applications for hypersonic vehicles – problems associated with supersonic combustion – engine/airframe integration aspects of hypersonic vehicles – various types scramjet combustors – fuel injection schemes in scramjet combustors.

UNIT II Chemical Rocket Propulsion **9**

Operating principle – specific impulse of a rocket – internal ballistics – performance characteristics of rockets – simple rocket design problems – types of igniters- Rocket nozzle classification – preliminary concepts in nozzle-less propulsion – air augmented rockets – pulse rocket motors – static testing of rockets & instrumentation –safety considerations

UNIT III Solid Rocket Propulsion **9**

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.

UNIT IV Liquid and Hybrid Rocket Propulsion **9**

Salient features of liquid propellant rockets – selection of liquid propellants – various feed systems and injectors for liquid propellant rockets -thrust control and 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.

UNIT V Advanced Propulsion Systems **9**

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 – current scenario of advanced propulsion projects worldwide

Total: 45 periods

Course Outcomes: At the end of the course, the student will be able to

CO1: Analyse the ramjet and hypersonic air breathing propulsion systems. ``

CO2: To evaluate the rocket propulsion systems

CO3: Create the applications of solid propulsion systems

CO4: Evaluate the applications and principles of liquid and Hybrid propulsion systems

CO5: To import knowledge about the advanced propulsion technique used for interplanetary mission.

CO's PO's & PSO's MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	3	2	2	3	-	-	-	-	1	-	1	-	3	3
CO2	3	2	2	2	1	-	-	-	-	1	-	1	-	3	2
CO3	2	3	2	3	2	1	1	-	-	-	1	2	2	2	1
CO4	2	2	2	3	2	1	1		-	-	1	2	2	1	1
CO5	3	2	3	3	3	1	-1		1	1	2	2	2	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Mathur, M.L., and Sharma, R.P., "Gas Turbine, Jet and Rocket Propulsion", Standard Publishers and Distributors, Delhi, 2nd edition 2014.

2. Sutton, G.P., "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 9th Edition, 2017

REFERENCE BOOKS:

1. Hill, P.G. & Peterson, C.R. "Mechanics & Thermodynamics of Propulsion" Second Edition Dorling Kindersley India 2009.

2. Robert G. Jahn, "Physics of Electric Propulsion Dover publications" Second Edition 2012.

WEB RESOURCE:

1. https://onlinecourses.nptel.ac.in/noc22_ae03/preview

AE650208 AIRCRAFT STRUCTURES - II

Course Category: Professional Core	Course Type: Theory with project	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To gain knowledge of unsymmetrical bending.
- . To impart knowledge of shear flow in open sections in aircraft.
- To impart knowledge of shear flow in closed sections in aircraft.
- To impart knowledge of buckling behavior of aircraft thin plates.
- To analyze the stress induced in aircraft wings and fuselage.

UNIT I UNSYMMETRICAL BENDING **9**

Bending of symmetric beams subject to skew loads - bending stresses in beams of unsymmetrical sections – generalized k-method, neutral axis method, principal axis method, Advantages and Disadvantages of three methods.

UNIT II SHEAR FLOW IN OPEN SECTIONS **9**

Thin-walled beams – concept of shear flow – the shear centre and its determination – shear flow distribution in symmetrical and unsymmetrical thin-walled sections – structural idealization – shear flow variation in idealized sections-Applications of shear flow calculations.

UNIT III SHEAR FLOW IN CLOSED SECTIONS **9**

Bredt - Batho theory – single-cell and multi-cell tubes subject to torsion – shear flow distribution in thin-walled single & multi-cell structures subject to combined bending and torsion – with walls effective and ineffective in bending-Importance of shear flow & shear center determination.

UNIT IV BUCKLING OF PLATES **9**

Governing differential equation - Buckling of thin plates - local buckling stress of thin-walled sections – crippling strength estimation- thin skin stringer panel-effective skin width –inter rivet buckling-skin stringer panel-Integrally stiffened panels-cutouts- Lightly loaded beams.

UNIT V STRESS ANALYSIS OF WING AND FUSELAGE **9**

Aircraft loads and its classification- Analysis the stress in wings and fuselage frames – shear force and bending moment distribution over the aircraft wing and fuselage – shear flow in thin-webbed beams with parallel and non-parallel flanges – complete tension field beam. **TOTAL: 45 PERIODS**

COURSE OUTCOMES:

At the end of this course the students will be able to:

CO1: Evaluate about unsymmetrical bending an aircraft.

CO2: Analyze the shear flow in open section of aircraft structure.

CO3: Analyze the shear flow in closed section of aircraft structure.

CO4: Analyze about buckling of air craft thin plates.

CO5: Analyze the aircraft real structural components such as wings and fuselage.

TEXT BOOKS:

1. Megson, T.M.G., "Aircraft Structures for Engineering Students", Fifth Edition Elsevier Aerospace Engineering series, 2021.

2.Peery, D.J., and Azar, J.J., "Aircraft Structures", Second Edition, McGraw–Hill, 2015.

REFERENCE BOOKS:

1.Bruhn. E.H. "Analysis and Design of Flight vehicles Structures", Fourth edition Tri – state off set company, USA, 2008.

2.Rivello, R.M., "Theory and Analysis of Flight Structures", Third edition McGraw Hl 2009.

3.Howard D Curtis, "Fundamentals of Aircraft Structural Analysis", Second edition WCB-McGraw Hill, 2005.

WEB RESOURCE:

1. https://archive.nptel.ac.in/courses/112/101/112101095/

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2					2			2

CO2	3	2	2	3	3				2			2
CO3	3	2	3	3	3				2			2
CO4	3	3	2	3	3				2			2
CO5	3	3	3	3	3				3			2

AE650209 - AERODYNAMICS II					
Course Category: Professional Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		2	**1**	**0**	**3**

COURSE OBJECTIVES:

- To import knowledge about the concepts of compressibility,
- To analyze the theory behind the formation of shocks and expansion fans in Supersonic flows.
- To evaluate the methodology of measurements in Supersonic flows.
- To analyses the differential equations of motion for steady compressible flows.
- To evaluate the transonic flow overwing.

UNIT I COMPRESSIBLEFLOW- FUNDAMENTALS 9

Energy and momentum equations for compressible fluid flows, various regions of flows, reference velocities, stagnation state, velocity of sound, critical states, Mach number, critical Mach number, types of waves, Mach cone, Mach angle, effect of Mach number on compressibility

UNIT II NORMAL ANDOBLIQUE SHOCKS **9**

Governing equations, variation of flow parameters like static pressure, static temperature, density, stagnation pressure and entropy across the normal shock, Prandtl-Meyer equation, impossibility of Shock in subsonic flows, flow in convergent and divergent nozzle with shock, normal shock in Fanno and Rayleigh flows, flow with oblique shock (elementary treatment only

UNIT III WIND TUNNEL **9**

Types of wind tunnels - sub sonic wind tunnel, supersonic wind tunnel, projectile obstruction and shadow graph technique characteristics of swept wings, effects of thickness, camber and aspect ratio of wings, transonic are a rule.

UNIT IV JET PROPULSION **9**

Aircraft propulsion-types of jet engines-energy flow through jet engines, study of turbojet engine components – diffuser, compressor, combustion chamber, turbine and exhaust systems, performance of turbo jet engines- thrust, thrust power, propulsive and overall efficiencies, thrust augmentation in turbo jet engine, ram jet and pulse jet engines

UNIT V SPACE PROPULSION **9**

Characterization of Space Propulsion Devices - Rocket propulsion-rocket engines thrust equation - effective jet velocity specific impulse- rocket engine performance, solid and liquid propellants, comparison of different propulsion systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of this course the students will be able to:

CO1: Calculate the compressible flow through a duct of varying cross section.

CO2: Use quasi one-dimensional theory to analyze compressible flow problems.

CO3: Estimate fluid properties in Rayleigh and Fanno type flows.

CO4: Estimate the properties across normal and oblique shockwaves.

CO5: Predict the properties of transonic flows.

TEXT BOOKS:

1. Anderson J.D "Modern compressible flows: with Historical perspective", McGraw-Hill 5th Edition 2011.
2. L.J. Clancy, "Aerodynamics" Sterling Book House, 2011.

REFERENCE BOOKS:

1. Rathakrishnan, E., "Gas Dynamics", 7 th Edition, Prentice Hall of India, 2021.

2. Shapiro, A.H., "Dynamics and Thermodynamics of Compressible Fluid Flow Wiley, First edition 2017.

WEB RESOURCE:

1. https://archive.nptel.ac.in/courses/101/106/101106042/

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	2					3			3
CO2	2	3	3	3	3				2			2
CO3	2	3	2	3					2			2
CO4	2	3	2	3					2			2

CO5	2	3	2	3	2				2			2

AE650304 AIRCRAFT STRUCTURES LAB					
Course Category: Program Core	**Course Type: Practical**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**1.5**

COURSE OBJECTIVES:

To study experimentally the load deflection characteristics structural materials under different types of loads.

LIST OF EXPERIMENTS

1.Determination of Young's modulus, yield stress, ultimate tensile strength.
2. Stress and breaking strength of steel using mechanical extensometers.
3.Determination of Young's modulus of aluminum using mechanical extensometers.
4. Deflection of beams with various end conditions.
5. Determination of Buckling load in Column.
6. Unsymmetrical bending of Z-section beams.
7. Shear Centre location for open channel sections.
8. Shear Centre location for closed D-sections.
9. Determination of Constant strength of the beam.
10. Determination of natural frequencies of cantilever beams.

.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Practical behaviour of aircraft structural Components Under different loading conditions.

CO2: Student will have hands-on experience in the area of testing of structural components.

CO3: Student will able to demonstrate the basics experimental techniques in photo elasticity.

CO4: Student will have an exposure to data interpretation/analysis of vibration measuring Instruments.

CO5: Student will have practical knowledge in the field of fabrication and testing of Composite material specimen.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3		3				2		3	
CO2	3	3	3		3		3		2		2	
CO3	3	2	2		3				2		2	
CO4	3	2	2		3				2		3	
CO5	3	3	3		3		3		2		2	

1- low, 2 - medium, 3 - high, '-' no correlation

AE650305- SURFACE AND SOLID MODELLING OF AIRCRAFT COMPONENTS LAB					
Course Category: Professional Core	**Course Type: Practical**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**1.5**

COURSE OBJECTIVES:

- To introduce the concept of design and drafting of an aircraft structural component using cad modelling package.

LIST OF EXPERIMENTS

1.Execution of two dimensional (2D) drawings using cad modeling software.
2.Execution of isometric drawings using cad modeling software.
3.Execution of three dimensional (3D) drawings using cad modeling software.
4.Design and modeling aircraft wing of a NACA series using cad modeling software.
5.Design and modeling aircraft wing ribs and spars using cad modeling software.
6.Design and modeling of rocket nozzle using cad modeling software.
7.Modeling the aircraft wing with blended winglet.
8.Assemble the components of landing gear and detailing the parts.
9.Study of CAD data exchange standards in the modeling industry.
10.Study of Augmented reality and 3D Printing role in CAD industry.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: To analyse basic aircraft and its components.

CO2: To create the solid and sheet metal three dimensional drawings.

CO3: To evaluate the assembly of aircraft components.

CO4: To analyse the standard formats for exchanging CAD data between different cad modelling packages.

CO5: To evaluate recent technologies implemented in aircraft design.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3		3				2		3	
CO2	3	3	3		3		3		2		2	
CO3	3	2	2		3				2		2	
CO4	3	2	2		3				2		3	
CO5	3	3	3		3		3		2		2	

1- low, 2 - medium, 3 - high, '-' no correlation

AE650503 - INTEGRATED APTITUDE SKILLS - I (HIGHER)					
Course Category: EEC	Course Type: Skill Based Course	L	T	P	C
		0	0	2	1*

COURSE OBJECTIVES:

To impart knowledge on the following Topics,

- Solve aptitude, logical and questions.
- Excel the talents of students in logical Verbal reasoning Analysis
- The non-verbal Reasoning Analysis
- enable the students to speak and write in English without making any mistakes
- Excel the students in mock interview, group discussion.

UNIT 1: QUANTITATIVE APTITUDE	**6**

Percentage - Ratio & Proportions - Pipes & Cisterns - Permutations & Combinations - Partnership - Allegation (Or) Mixture - Races & Games - Stocks & Shares - Height & Distance - True Discount & Banker's Discount - Probability - Mensuration (Area, Volume & Surface Area) - Interest (Simple Interest, Compound Interest) - Logarithm - Chain Rule - Data Interpretation (Tabulation, Bar Chart, Pie Chart, Line Graphs)

UNIT 2: LOGICAL REASONING-VERBAL REASONING	**6**

Logic - Statement – Argument, Assumptions, Courses of action, Conclusion - Deriving Conclusion from passages - Theme Detection - Cause and Effect reasoning

UNIT 3: LOGICAL REASONING- NONVERBAL REASONING:	**6**

Series - Analogy - Classification - Analytical Reasoning - Mirror Images - Water Images - Spotting out the embedded figures - Completion of incomplete patterns - Figure Matrix - Paper Folding - Paper Cutting - Rule Detection - Grouping of identical figures - Cubes and Dice - Dot Situation - Construction of squares and triangles - Figure formation and analysis

UNIT 4: VERBAL ABILITY	6

Concord - Cloze Passage - Analogies or Reverse Analogies - Jumbled Sentences - Error Deduction - Reading Comprehension - Paragraph Formation - Completing Statements - Usage of Prepositions - Inference - Verification of Truth from the Statements - Change of Speech

UNIT V: PRACTICALS	**6**

Extempore speech, Group Discussion, Mock Interview

TOTAL: 30 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1	Evaluate the basic concepts of quantitative ability.
CO2	Evaluate the basic concepts of verbal logical reasoning Skills.
CO3	Acquire satisfactory competency in use of nonverbal reasoning.
CO4	Analyse the concepts in verbal ability
CO5	Acquire satisfactory competency in Group Discussion and Mock Interview

CO-PO MAPPING

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	1	2	2	2	2	2	3	2	2	2	-	-
CO2	3	3	2	3	3	2	2	2	2	3	1	2	-	-
CO3	2	3	2	3	2	2	2	2	3	2	2	1	-	-
CO4	2	3	2	2	2	2	3	3	2	2	1	2	-	-
CO5	2	3	3	3	2	3	3	3	2	2	2	3	-	-

1- Low, 2 - Medium, 3 - High, '-' No Correlation

TEXT BOOKS:

1. Legal Aptitude & Reasoning for CLAT & AILET Exams. N.p., Disha Publications, 2021.

2.Agarwal R.S, "Quantitative Aptitude," S.Chand and Company Pvt. Ltd., New Delhi, First Edition 1989, Reprint, 2016

REFERENCE BOOKS:

1. Jaikishan, and Premkishan. How to Crack Test of Reasoning. India, Arihant Publication India Limited, 2018.

2.Anand P A, "Quantitative Aptitude," Wiley India Pvt. Ltd., New Delhi, Edition, 2016.

WEB RESOURCES:

Aptitude Skills
1. https://www.udemy.com/course/quant_aptitud_tricks_and_shortcuts
Reasoning
2. https://aptitudeclass.com/

AE650801 - AIRCRAFT REGULATION

Course Category: Programme Mandatory	**Course Type: Theory**	**L**	**T**	**P**	**C**
		2*	**0**	**0**	**0**
COURSE OBJECTIVES:					

- To provide a comprehensive understanding of aircraft regulation and certification processes.
- To impart knowledge to the students with the legal and safety requirements governing aircraft design, manufacturing, operation, and maintenance.
- To explore international and national regulatory bodies and their roles in ensuring aviation safety and compliance.
- To analyze case studies and real-world scenarios to apply regulatory concepts in practical contexts.
- To equip students with the knowledge and skills necessary to navigate the complex regulatory landscape in the aerospace industry.

UNIT I INTRODUCTION TO AIRCRAFT REGULATION AND CERTIFICATION	**6**
Overview of aviation regulatory bodies (FAA, EASA, ICAO, etc.) - History and evolution of aircraft regulation - Airworthiness standards and certification requirements - Regulatory compliance and enforcement mechanisms - Aircraft registration and marking requirements - Maintenance and inspection procedures for regulatory compliance - Airworthiness Directives (ADs) and their importance -Role of human factors in regulatory compliance.	
UNIT II INTERNATIONAL AGREEMENTS AND ORGANIZATIONS	**6**
The Convention of Chicago and its implications - International Civil Aviation Organization (ICAO): objectives, composition, and functions -Other international agreements (Tokyo Convention, Montreal Convention, etc.) - Indian regulatory framework: DGCA, Aircraft Act 1934, Indian Aircraft Rul [23] - Harmonization efforts and challenges in international aviation regulations - Cross-border operations and regulatory considerations - Environmental regulations and their impact on international aviation - Emerging trends in global aviation regulation and policy-making	
UNIT III AIR NAVIGATION AND LEGAL ASPECTS	**6**
Principles of air navigation and sovereignty - Flight over territory: rights, regulations, and documents - International standards and recommended practices (SARPs) - Civil Aviation Requirements (CARs) and Warsaw Convention - Air traffic management and airspace classification - Aircraft accident investigation procedures and legal aspects - Liability issues in air navigation and aviation law - Legal considerations in unmanned aerial systems (UAS) operations	
UNIT IV PILOT-IN-COMMAND (PIC) AUTHORITY AND OPERATOR'S LIABILITIES	**6**
PIC authority and responsibility for safety and security - Liability of operators and pilots towards persons and goods on the ground - Commercial practices and associated rules in aviation - Crew training and competency requirements - Licensing and certification procedures for pilots and operators - Insurance requirements for aviation operations - Contractual agreements and their legal implications in aviation	

UNIT V CASE STUDIES AND PRACTICAL APPLICATIONS	6

Analysis of international agreements in real-world scenarios - Examination of legal aspects and liabilities in aircraft operations - Group discussions and presentations on commercial practices and regulations - Simulation exercises on regulatory compliance scenarios - Research projects on emerging regulatory issues in aviation - Presentation of case studies on aviation accidents/incidents and regulatory responses - Guest lectures from industry experts on current regulatory challenges and solutions.

TOTAL: 30PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Demonstrate a comprehensive knowledge about the aircraft regulation and certification processes, including international and national regulatory frameworks.

CO2: Analyze and interpret key international agreements and organizations governing aviation, such as the Convention of Chicago and the International Civil Aviation Organization (ICAO).

CO3: Apply knowledge of air navigation principles and legal aspects to ensure compliance with airworthiness standards, recommended practices, and civil aviation requirements.

CO4: Assess the authority and responsibilities of the Pilot-in-Command (PIC) and operators concerning safety, security, and liability in aircraft operations.

CO5: Evaluate commercial practices and associated rules in aviation, including contractual agreements, insurance requirements, and licensing procedures.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	-	-	2	-	-	-	2	-	2	2	2	2
CO2	2	3	2	-	-	2	-	-	-	2	-	2	2	2	
CO3	2	2	2	-	-	2	-	-	-	2	-	2	2	2	2
CO4	2	2	2	-	-	2	-	-	-	2	-	2	2		2
CO5	2	2	2	-	-	2	-	-	-	2	-	2	2	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.Scott Hamilton, "Understanding Aviation Regulation", Routledge, 2018.

2.Regulatory texts and guidelines provided by relevant aviation authorities, 2021

REFERENCE BOOKS:

2.Sarah E. MacLeod, "Understanding Aircraft Certification", ASA, 2013.

3.Allan Seabridge, "Aviation Regulation in the EU", Routledge, 2017.

SEMESTER - 6

AE660210– AIRCRAFT STRUCTURES AND REPAIR					
Course Category: Programme Core	**Course Type: Theory with Practical Component**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

- To impart knowledge about aircraft structure maintenance and repair
- To impart knowledge about the safety precautions and procedure of aircraft structure
- To evaluate the troubleshooting procedure
- To analyze the basic welding concepts in structural components
- To analyze on the applications of MEMS to various disciplines

UNIT 1: WELDING IN AIRCRAFT STRUCTURAL COMPONENTS	**6**

Equipments used in welding shop and their maintenance - Ensuring quality welds - Sheet metal repair and maintenance: Selection of materials - Repair schemes; Fabrication of replacement patches; Tools - power/hand; Repair techniques; Close tolerance fasteners; Sealing compounds; forming/shaping.

UNIT 2: PLASTICS AND COMPOSITES IN AIRCRAFT	**6**

Types of plastics used in aircraft - Maintenance and repair of plastic components - Repair of cracks, holes etc., and various repairs schemes - Scopes. leaning of fibre reinforced plastic (FRP) materials; Vacuum-bag process. Special precautions – Autoclaves

UNIT 3: AIRCRAFT JACKING, ASSEMBLY AND RIGGING	**6**

Aircraft jacking and weighing and C.G. Location. Balancing of control surfaces - Inspection maintenance. Helicopter flight controls. Tracking and balancing of main rotor. Aircraft Electrical System, Inspection of Aircraft and Basic Aircraft Design.

UNIT 4: HYDRAULIC AND REPAIR IN AIRCRAFT	**6**

Trouble shooting and maintenance practices - Installation and maintenance of Instruments -handling - Testing - Inspection. Inspection and maintenance of auxiliary systems - Fire protection systems - Ice protection system - Rain removal system -Position and warning system – Auxiliary Power Units (APUs)

UNIT 5: SAFETY PRACTICES IN AIRCRAFT	**6**

Aircraft safety systems - Air traffic safety system - Airport safety - Aviation safety management system - Hazardous materials storage and handling - Aircraft furnishing practices - Trouble shooting. Theory and practices.

TOTAL: 30 PERIODS

PRACTICAL COMPONENT

1. Welding of aircraft structural component.
2. Break test - Repair Schemes; FRP/honeycomb sandwich materials.
3. Aircraft jacking and weighing and C.G. Location.
4. Inspection and maintenance of air-conditioning and pressurization system, water and waste system.

5. Hazardous materials storage and handling **TOTAL: 15 PERIODS**

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Analyse the welding, brazing process with the requirements of the process and significance of NDT

CO2: Evaluate the various maintenance practices in plastic and composite parts of aircraft

CO3: Comprehend the precautionary steps involved in rigging, Jacking process

CO4: Analyse the working methodology of basic aircraft systems

CO5: Evaluate about safety practices and troubleshooting on an aircraft

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	-	-	-	-	-	-	-	-	-	-	-	1	-	3
CO2	2	1	1	2	1	-	-	-	-	-	1	-	-	-	1
CO3	-	1	1	1	2	-	-	-	-	-	1	1	1	-	-
CO4	1	1	2	1	2	-	-	-	-	-	1	1	-	-	1
CO5	-	2	1	1	2	2	1	-	-	-	1	-	1	-	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Kroes, Watkins, Delp, "Aircraft Maintenance and Repair ", McGraw Hill, New York, 7th edition,2021.

2. Ronald Sterkenburg, 'Aircraft Maintenance & Repair, 8th Edition", McGraw Hill, 9th edition, 2023.

REFERENCE BOOKS:

1. Larry Reithmeir, "Aircraft Repair Manual ", Palamar Books, Marquette, 8th edition, 2013.

2. Clarence C. Rodrigues, and Stephen K. Cusick, Commercial Aviation Safety, 5th Edition, McGraw-Hill Education, 5th edition, 2012.

3. Tai Ran Hsu, "Aircraft Structures for Engineering Students" Elsevier, New Delhi, 6th edition, 2022.

WEB RESOURCE:

1. Aircraft Structures and Repair: https://nptel.ac.in/courses/101105084

AE660211 – FLIGHT DYNAMICS						
Course Category: Programme Core	**Course Type: Theory with Project**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

- To impart knowledge about the performance of airplanes under various operating conditions.
- To analyze the static and dynamic response of aircraft for both voluntary and involuntary changes in flight conditions.
- Evaluate the dynamic longitudinal stability, stability derivatives, modes and stability criterion, lateral and directional dynamic stability.

UNIT 1: STATIC LONGITUDINAL STABILITY AND CONTROL (STICKFIXED) **9**

Degree of freedom of rigid bodies in space - Static and dynamic stability - Purpose of controls in airplanes - Inherently stable and marginal stable airplanes – Static, Longitudinal stability - Stick fixed stability - Basic equilibrium equation - Stability criterion - Effects of fuselage and nacelle - Influence of CG location - Stick fixed neutral point and static margin.

UNIT 2: STATIC LONGITUDINAL STABILITY AND CONTROL (STICK FREE) **9**

Stick free stability-Hinge moment coefficient - Stick free neutral points-Symmetric maneuvers - Stick force gradients - Stick force per 'g' - Power effects - Aerodynamic balancing. Determination of neutral points and maneuver points from flight test.

UNIT 3: MANEUVERING FLIGHT AND DIRECTIONAL STABILITY **9**

Effect of acceleration on airplane balancing, Elevator angle per g, Asymmetric flight, Weather cock stability, contribution of different parts of Airplane, Rudder Fixed and Rudder free static directional stability. Peddle fixed and peddle stability, roll control reversal.

UNIT 4: LATERAL STABILITY AND CONTROL **9**

Dihedral effect - Lateral control - Coupling between rolling and yawing moments - Roll stability and control, Adverse yaw effects - Aileron reversal - Static directional stability - Weather cocking effect - Rudder requirements - One engine inoperative condition - Rudder lock.

UNIT 5: DYNAMIC STABILITY **9**

Dynamic longitudinal stability: Equations of motion - Stability derivatives - Modes and stability criterion - Effect of freeing-the stick. Dynamic stability - Spiral, divergence, Dutch roll, auto rotation, spin, approximation of longitudinal and lateral modes, Factors affecting time period and damping.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Evaluate the performance in level flight, minimum drag and power required, climbing, gliding and turning flight, v-n diagram and load factor.

CO2: Knowledge about degrees of stability, stick fixed and stick free stability, stability criteria, effect of fuselage and CG location, stick forces, aerodynamic balancing.

CO3: Analyse the lateral control, rolling and yawing moments, static directional stability, rudder and aileron control requirements and rudder lock.

CO4: Evaluate the dynamic longitudinal stability, stability derivatives, modes and stability criterion, lateral and

directional dynamic stability.

CO5: Interpret the Dynamic Stability, Equation of Motion & understand the static and dynamic response of aircraft for both voluntary and involuntary changes in flight conditions.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	-	-	-	-	2	1	-	2	-	3	3
CO2	3	2	2	3	-	-	-	-	2	1	-	2	-	3	2
CO3	3	3	2	3	-	-	-	-	2	-	1	2	2	2	1
CO4	3	3	3	3	-	-	-	-	2	-	1	2	2	1	1
CO5	3	3	3	3	-	-	-	-	2	1	2	2	2	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Perkins, C.D., and Hage, R.E., Airplane Performance stability and Control, wiley india Pvt Ltd, 3rd edition, 2020.

2. Nelson, R.C. Flight Stability and Automatic Control, second edition McGraw-Hill Book Co.,3rd edition, 2023.

REFERENCE BOOKS:

1. Etkin, B., Dynamics of Flight Stability and Control, Third edition, Wiley India Pvt ltd, 4th edition 2018.

2. Babister, A.W., Aircraft Dynamic Stability and Response, Pergamon Press, 7th edition 2013.

3. Yechout, T. R. et al.,Introduction to Aircraft Flight Mechanics , AIAA education, 2nd edition, 2017.

WEB RESOURCE:

1. https://nptel.ac.in/courses/101106043

AE660212 - FINITE ELEMENT ANALYSIS					
Course Category: Programme Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		2	**1**	**0**	**3**

COURSE OBJECTIVES:

- To understand the basic concepts in finite element analysis.
- To impart knowledge about formulation and the procedure of the finite element method and its application to varieties of problems.
- To analyse about continuum elements
- To illustrate about iso parametric element.
- To evaluate heat transfer problems using finite element analysis

UNIT I BASIC CONCEPTS **9**

Various approximate methods – variation approach and weighted residual approach application to structural mechanics problems - finite difference methods- governing equation and convergence criteria of finite element method.

UNIT II DISCRETE ELEMENTS **9**

Bar elements, uniform section, mechanical and thermal loading, varying section, 2D and 3D truss element. Degrees of freedom, Beam element - problems for various loadings and boundary conditions – 2D and 3D Frame elements - Use of local and natural coordinates.

UNIT III CONTINUUM ELEMENTS **9**

Basics on plane stress and plane strain condition, Constant and linear strain triangular elements and its shape function derivation, stress strain relationship for plane stress and plane strain problems and axi symmetric element. Plane stress, plane strain and axi-symmetric problems.

UNIT IV ISOPARAMETRIC ELEMENTS **9**

Definitions, Shape function for 4, 8 and 9 nodal quadrilateral elements, stiffness matrix and consistent load vector, evaluation of element matrices using numerical integration.

UNIT V HEAT TRANSFER PROBLEMS **9**

Heat transfer problems, One dimensional conduction Quadratic element, One dimensional conduction with convection, Heat transfer in two dimensions, steady state fin problems, Time dependent Heat transfer problems,

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Evaluate the finite element steps and understand the convergence of the problem

CO2: Analyse the stiffness matrix for bar, beam and frame problems using suitable boundary condition.

CO3: Interpret the plane stress and plane strain condition are used to understand 2d structures.

CO4: Analyse the 2d and 3d structures using isoparametric elements

CO5: Analyse the fluid flow and heat transfer problems

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3				2			3
CO2	3	3	3	3					2			2
CO3	3	2	2	2					2			2
CO4	3	3	3	3	3				2			2
CO5	3	3	3	3	3				2			2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. David Hutton, "Fundamentals of Finite Element Analysis" Tata McGraw-Hill Publication, New Delhi, 2nd edition 2005.

2. S.S.Rao - Finite Element Methods in Engineering (Butterworth &Heinemann, UK), 6th edition, 2022.

REFERENCE BOOKS:

1. C.S. Krishnamurthy - Finite Element Analysis (Tata McGraw Hill, Delhi, India) 2nd edition, 2017.

2. T.R. Chandrapatha & A.D. Belegundu – Introduction to Finite Elements in Engineering (Printice Hall of India, New Delhi, India), 4th edition, 2017.

3. J.N. Reddy - An Introduction to Finite Element Method (Mc Graw Hill, USA), 5th edition,2019.

WEB RESOURCE:

1. https://archive.nptel.ac.in/courses/112/104/112104193/

AE660306 - AIRCRAFT DESIGN PROJECT – I					
Course Category: Programme Core	**Course Type: Practical**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**1.5**

COURSE OBJECTIVES:

- To demonstrate the data collections of different airplanes.
- To analyse the experience in weight estimations.
- To impart knowledge about geometric parameters of airplanes.
- To evaluate the performance characteristics of airplanes.
- To investigate the stability of the system when subjected to disturbance.

LIST OF EXPERIMENTS

1. Comparative configuration study of different types of aircraft.
2. Comparative study on specification and performance details of aircraft.
3. Preparation of comparative datasheets.
4. Work sheet layout procedures.
5. Comparative graphs preparation and selection of main parameters for the design.
6. Preliminary weight estimations, selection of main parameters
7. Power plant selection, Aerofoil selection, Wing tail and control surfaces.
8. Preparation of layouts of balance diagram and three view drawings.
9. Drag estimation in the aircraft.
10. Detailed performance calculations and stability estimates.

TOTAL: 45 PERIODS

COURSE OUTCOMES: Upon completion of the course, Students will be able to

CO1: Create preliminary design of an aircraft starting from data collection to satisfy mission specifications.

CO2: Evaluate the estimation of geometric and design parameters of an airplane.

CO3: Create the procedure involved in weight estimation, power plant selection, and estimation of the performance parameters.

CO4: Create the design of a system, component, or process to meet requirements for aircraft systems.

CO5: Interpret the integration of engineering practices in such subjects as aerodynamics, structures, propulsion, and flight mechanics.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		3	3	3	3				2			2
CO2		3	3	2	2				2			2
CO3		3	3	2	2		3		2			2
CO4		2	3	3					2			2
CO5		3	2	2			3		2			2

1- low, 2 - medium, 3 - high, '-' no correlation

AE660307 - SIMULATION OF AIRCRAFT STRUCTURAL COMPONENTS

Course Category: Program Core	**Course Type: Practical**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**1.5**

COURSE OBJECTIVES:

- To develop skills in computational fluid dynamics to address engineering problems.
- To analyse the basic structure and capabilities of current commercial CFD codes.
- To evaluate the finite element analysis and finite element methods.
- Impart knowledge about ANSYS Workbench FEA numerical engineering problem solver.
- Analyse the aircraft nozzle and diffuser using ANSYS software.

LIST OF EXPERIMENTS

1. Study of basics in ANSYS.
2. Stress analysis of a plate with a circular hole
3. Stress analysis of rectangular L bracket
4. Stress analysis of cantilever beam
5. Introduction to ANSYS fluent
6. Subsonic flow in convergent and divergent nozzle
7. Pressure distribution over a symmetric aero foil
8. Flow through a diffuser
9. Shock waves boundary layer intersection over a flat plate
10. Circulation of the lift over a circular cylinder

TOTAL: 45 PERIODS

COURSE OUTCOMES: Upon completion of the course, Students will be able to

1. Analyse the aircraft components using finite element analysis and finite element methods.
2. Analyse the ANSYS Workbench FEA numerical engineering problem solver.
3. Create ANSYS Workbench FEA numerical engineering problem solver
4. Interpret the Finite Difference and Finite Volume methods in CFD modelling
5. Evaluate the aircraft nozzle and diffuser performance using ANSYS software.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		3	3	3	3				2			2
CO2		3	3	2	2				2			2
CO3		3	3	2	2		3		2			2
CO4		2	3	3					2			2
CO5		3	2	2			3		2			2

1- low, 2 - medium, 3 - high, '-' no correlation

ME660504 - TRAINING IN CENTRE FOR EXCELLENCE IN ROBOTICS, SENSOR AND PLC (Common to MECH, MAE& AERO)

Course Category: EEC	**Course Type:** Skill based course	**L**	**T**	**P**	**C**
		0	**0**	**2**	**1***

COURSE OBJECTIVES:

- To evaluate the basic fundamentals of Mechatronics.
- To provide an overview of fundamentals of automation.
- To evaluate the application in engineering mechanisms.

ROBOTICS **10**

Basic Concepts: Definition and origin of robotics, different types of robotics, various generations of robots, degrees of freedom, Asimov's laws of robotics, dynamic stabilization of robots. Manipulators, Actuators and Grippers: Construction of manipulators, manipulator dynamics and force control, electronic and pneumatic manipulator control circuits, end effectors, U various types of grippers, design considerations.

SENSORS FUNDAMENTALS AND ITS APPLICATIONS **10**

Sensors Fundamentals: Basic sensor technology, Sensor Systems, Sensor Characteristics, System Characteristics, Instrument Selection, Data acquisition, Installation. Process of developing sensors, sensor arrays smart sensors, Industrial sensor networking basic Elements. Smart sensors, sensor networks in R & D, sensors and networks, industrial network and automation.

PROGRAMMABLE LOGIC CONTROLLER **10**

Define PLC, Technical Definition of PLC, Advantages, characteristics functions of A PLC, Chronological Evolution of PLC, Types of PLC, Unitary PLC, Modular PLC, Small PLC, Medium PLC, Large PLC, Block Diagram of PLC: Input/output (I/O) section, Processor Section, Power supply, Memory central Processing Unit: Processor Software / Executive Software, Multi asking, Languages, Ladder Language.

TOTAL: 30 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: To understand the various graphical representation system in Robotics

CO2: To understand the principle working in Mechatronics.

CO3: To learn the fundamentals of sensors.

CO's PO's & PSO's MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	3	3	2	-	-	2	2	2	3	3	2
CO2	3	2	3	2	2	2	-	-	2	2	2	3	3	2
CO3	3	2	3	2	2	1	-	-	2	2	2	3	3	2

1- low, 2 - medium, 3 - high, '-' no correlation

IM660403 – PROFESSIONAL ETHICS (Common All Branches)

Course Category: Institute mandatory	Course Type: Theory	L	T	P	C
		2*	0	0	0

COURSE OBJECTIVES:

- Students will evaluate the importance of Values and Ethics in their Personal lives and professional careers
- The students will learn the rights and responsibilities
- Responsibilities of employee, team member and a global citizen.

UNIT I: INTRODUCTION TO PROFESSIONAL ETHICS	**6**

Basic Concepts, Governing Ethics, Personal &Professional Ethics, Ethical Dilemmas, Life Skills, Emotional Intelligence, Thoughts of Ethics, Value Education, Dimensions of Ethics.

UNIT II: BASIC THEORIES	**6**

Basic Ethical Principles, Moral Developments, Deontology, Utilitarianism, Virtue Theory, Rights Theory, Casuist Theory, Moral Absolution, Moral Rationalism, Moral Pluralism, Ethical Egoism, Feminist Consequentialism, Moral Issues, Moral Dilemmas, Moral Autonomy.

UNIT III: PROFESSIONAL PRACTICES IN ENGINEERING	**6**

Professions and Norms of Professional Conduct, Norms of Professional Conduct vs. Profession; Responsibilities, Obligations and Moral Values in Professional Ethics, Professional codes of ethics,
the limits of predictability and responsibilities of the engineering profession, Central Responsibilities of Engineers.

UNIT IV: WORK PLACE RIGHTS & RESPONSIBILITIES	6

Ethics in changing domains of Research, Engineers and Managers; Organizational Complaint Procedure, difference of Professional Judgment with in the Nuclear Regulatory Commission (NRC), the Hanford Nuclear Reservation. Ethics in changing domains of research.

UNIT V: GLOBAL ISSUES IN PROFESSIONAL ETHICS	6

Introduction–Current Scenario, Technology Globalization of MNCs, International Trade, World Summits, Issues, Business Ethics and Corporate Governance, Sustainable Development Ecosystem, Energy Concerns, Ozone Deflection, Pollution, Ethics in Manufacturing and Marketing, Media Ethics; War Ethics; Bio Ethics, Intellectual Property Rights

TOTAL: 30 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Analyse the basic purpose of profession, professional ethics and various moral and social issues

CO2: Interpret the professional rights and responsibilities of an Engineer, safety and risk benefit analysis

CO3: Acquiring knowledge of various roles of Engineer In applying ethical principles

CO4: Evaluate the safety precaution on nuclear power plant and research-oriented analysis.

CO5: Evaluate the global issues, sustainable development and eco system.

CO's PO's & PSO's MAPPING														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	2	-	-	-	2	-	-
CO2	3	2	2	-	-	-	-	2	-	-	-	2	-	-
CO3	3	2	2	-	-	-	-	2	-	-	-	2	-	-
CO4	3	2	2	-	-	-	-	2	-	-	-	2	-	-
CO5	3	2	2	-	-	-	-	2	-	-	-	2	-	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Professional Ethics: R. Subramanian, Oxford University Press, Delhi, 2nd edition, 2015.
2. Ethics in Engineering Practice & Research, Caroline Whitbeck, Cambridge University Press 2nd edition, 2015

REFERENCE BOOKS:

1. Engineering Ethics, Concepts Cases: Charles E. Harris Jr., Michael S Pritchard, Michae l J Rabins, Cengage learning, 4th edition, 2015.
2. Business Ethics concepts & Cases: Manuel G Velasquez, PHI, 6th edition, 2008.

WEB RESOURCE:

1. https://online courses.nptel.ac.in/noc22_mg54/preview

VERTICALS 1 TO 8

Vertical-1
AERODYNAMICS AND PROPULSION
CURRICULUM

S. No.	Course Code	Course Title	Classification		L	T	P	C
1	AE606101	Aircraft Design	PEC	Theory	3	0	0	3
2	AE606102	Advanced propulsion systems	PEC	Theory	3	0	0	3
3	AE606103	Hypersonic aerodynamics	PEC	Theory	3	0	0	3
4	AE606104	High Speed Aerodynamics (NPTEL)	PEC	Theory	3	0	0	3
5	AE606105	Wind Tunnel Techniques (NPTEL)	PEC	Theory	3	0	0	3
6	AE606106	Structural Dynamics (NPTEL)	PEC	Theory	3	0	0	3
7	AE606107	Aerospace Propulsion (NPTEL)	PEC	Theory	3	0	0	3
8	AE606108	Gas Dynamics and Jet Propulsion	PEC	Theory	3	0	0	3

AE606101 - AIRCRAFT DESIGN						
Course Category: Vertical 1	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- Analyze various concepts related to aircraft design.
- Estimate weight & geometrical parameters of different types of aircrafts.
- Analyze aerodynamic and stability characteristics during design of different types of aircrafts.
- Analyze and estimate performance parameters during aircraft design.
- Analyze and estimate structural aspects and apply in aircraft design.

UNIT 1: INTRODUCTION	**9**

Aircraft design, Requirements and specifications, Airworthiness requirements, Importance of weight, Aerodynamic and structural design considerations, Classifications of airplane, Concept of configuration, Features of special purpose airplanes, unmanned aerial vehicles and their features, Control configured vehicles.

UNIT 2: SYMMETRICAL MANEUVERING LOADS	**9**

Classical methods of estimating symmetrical maneuvering loads on a wing in flight, Basic flight loading conditions, Load factor, V-n diagram, Gust loads, Estimation of gust loads, Gust envelope, Use of panel methods to estimate air load distribution on a wing.

UNIT 3: STRUCTURAL INTEGRATION	**9**

Structural layout of straight, tapered and swept (forward and aft) wings, Cockpit and passenger cabin layout, Layout of flight and engine controls, Wing fuselage joining methods, All metal airplane considerations, Use of composite materials, Preparation of 3-views, CG location.

UNIT 4: COMPLETE DESIGN PROBLEM	**9**

Preparation of conceptual design of an airplane from given specifications, Use and analysis of existing designs for this purpose, Design of airframe for the specifications, Prediction of performance, stability and control, Relaxed stability, Selection of engines from all considerations with all details, Freezing the design, Preparation of preliminary drawings including 3 views and layout.

UNIT 5: WING DESIGN	**9**

Factors influencing selection of airfoil and plan form, Span wise air loads variation, Super critical wing, Stalling, take-off and landing considerations, BM and SF diagrams, Design principles of all

metal, stressed skin wing (Civil & Military airplane), Estimation of wing drag.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. The course enables students to understand and apply various concepts related to aircraft design.

CO2.The course enables students to conceptually design various types of aircrafts.

CO3.Analyse aerodynamic and stability characteristics during design of different types of aircrafts.

CO4.Analyze and estimate performance parameters during aircraft design.

CO5.Analyze and estimate structural aspects and apply in aircraft design.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO2	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO3	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO4	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO5	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.D. P. Raymer, "Aircraft Design: A Conceptual Approach", 5 th Edition, AIAA Publication, 2012

2.DarrolStinton D., "The Design of the Aeroplane", 2nd Edition, Black Well Science, 2001.

3.J. D. Anderson Jr., "Aircraft Performance and Design", 3rd Edition, Tata McGrawHill, 2010.

REFERENCE BOOKS:

1.L.M.Nikolai, "Fundamentals of Aircraft Design", Illustrated edition , American Institute of Aeronautics & Astronautics; 2010

2.John J. Bertin and Russell M. Cummings , "Aerodynamics for Engineers", 5th Edition, Pearson Prentice Hall;

3. Advanced Vehicle Technology by Heinz Heisler MSc BSc FIMI MIRTE MCIT | 17 July 2002

148.

4. Advanced Motorsport Engineering: Units for Study at Level 3by Andrew Livesey | 1 September2011.

WEB RESOURCES:

1. Fundamentals of Electric vehicles: https://nptel.ac.in/courses/108106170

AE606102- ADVANCED PROPULSION SYSTEMS						
Course Category: Vertical 1	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To impart knowledge on the basic concepts of space propulsion.
- To learn about the physics of ionized gases
- To get familiarize with the types of nuclear rockets and the basic concepts of nuclear propulsion systems.
- To study about the radioisotope propulsion.
- To realise the importance of advanced space propulsion concepts

UNIT 1: INTRODUCTION TO SPACE PROPULSIONSYSTEMS	**9**

Historical outline, Scramjet Propulsion-Scramjet Inlets; Scramjet Performance, Chemical rocket Propulsion-Tri-propellants; Metalized Propellants; Free Radical Propulsion, Electric Propulsion, Micro propulsion - Micro Propulsion Requirements, MEMS and MEMS- Hybrid Propulsion Systems.

UNIT 2: BASIC CONCEPTS OF IONIZED GASES	**9**

Electromagnetic theory: electric charges and fields, currents, and magnetic fields, and applications to ionized gases. Atomic structure of gases - Ionization processes - Particle collisions in an ionized gas – Electrical conductivity of an ionized gas - Kinetic Theory, Introduction to plasma physics- Electrode phenomena.

UNIT 3: NUCLEAR ROCKET PROPULSION	**9**

Nuclear Rocket Engine Design and Performance, Types of Nuclear Rockets, Overall Engine Design, Nuclear Rocket Performance, Component Design, Nuclear Rocket Reactors, General Design Considerations, Reactor Core Materials, Thermal Design, Mechanical Design, Nuclear Design, Shielding, Nuclear Rocket Nozzles, General Design Considerations, Heat-Transfer Analysis, Over- all Problem, Hot-Gas Boundary, Cold-Gas Boundary.

UNIT 4: RADIOISOTOPE PROPULSION	**9**

Alternative Approaches, Direct Recoil Method, Thermal Heating Method, Basic Thruster Configurations, Propulsion System and Upper Stage, Relative Mission Capabilities, Primary Propulsion, Auxiliary Propulsion, Thruster Technology, Design Criteria, Performance, Safety, Heat Source Development, Radioisotope Fuel, Capsule Technology, General Considerations, Thermal Design, Fabrication and Non-Destructive Testing Techniques, Pressure Containment, Heat Source Simulation, Oxidation and Corrosion of Encapsulating Materials, Nozzle Performance.

UNIT 5: ADVANCED SPACE PROPULSION CONCEPTS	9

Introduction, General Consideration for Propulsion in Space, Power Supply, Propellant Storage and Handling Facilities, Electrostatic and Electromagnetic Thrusters, Advanced Electric Propulsion Systems for Space Vehicles, Sputtering, A Thrust Generation Mechanism, Sputtering Phenomena, Possible Performance of Sputtering Thrusters, Energy Efficiency of the Sputtering Process, Analyses of an Elementary Mission with Different Electric Thrusters, General Consideration, Performance Formula for Electric Thrusters, Optimization with Electric Thrusters.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Have knowledge on the basics and classification of space propulsion.

CO2: Comprehend the physics of ionized gases, their theories and particle collisions.

CO3: Demonstrate the working, types and performance of nuclear rockets with their design considerations.

CO4: Learn the basics of radioisotope propulsion with their performance studies.

CO5: Have knowledge on advanced methods of space propulsion systems with new thrust generation mechanisms.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	1	2	1	-	-	-	1	-	1	2	1	-
CO2	3	2	1	1	2	1	-	-	-	1	-	1	2	1	-
CO3	3	2	1	1	2	1	-	-	-	1	-	1	2	1	-
CO4	3	2	1	1	2	1	-	-	-	1	-	1	2	1	-
CO5	3	1	1	-	1	1	-	-	-	-	-	1	2	1	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Czysz, Paul A., Bruno, Claudio, Chudoba, Bernd "Future Spacecraft Propulsion Systems and Integration", Springer, Praxis Publishing Ltd, 2018.

2. George W. Sutton, "Engineering Magneto hydrodynamics", Dover Publications Inc., New York, 2006.

3. George P. Sutton & Oscar Biblarz, "Rocket Propulsion Elements, John Wiley & Sons Inc., NewYork, 9th Edition, 2016.

REFERENCE BOOKS:
1. Martin Tajmar, "Advanced Space Propulsion Systems" Springer Verlag GmbH, 2003.
2. Robert G. Jahn, "Physics of Electric Propulsion", McGraw-Hill Series, New York, 1968.
3. William J. Emrich, "Principles of Nuclear Rocket Propulsion" Elsevier Science, 2016.
WEB RESOURCES:
1.Advanced Propulsion: https://www.youtube.com/watch?v=537WEv1s-SA

AE606103 - HYPERSONIC AERODYNAMICS						
Course Category: Vertical 1	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To learn basics of hypersonic flow, shock wave, boundary layer interaction and aerodynamic heating.
- To extend the surface inclination methods for hypersonic inviscid flows.
- To explain the approximate methods for inviscid hypersonic flows
- To familiarize them with the aerodynamical aspects of hypersonic vehicles and the general.
- To understand the viscous interactions in hypersonic viscous flow.

UNIT 1: BASICS OF HYPERSONIC AERODYNAMICS	**9**
Thin shock layers – entropy layers – low density and high-density flows – hypersonic flight paths – hypersonic flight similarity parameters – shock wave and expansion wave relations of inviscid hypersonic flows.	
UNIT 2: SURFACE INCLINATION METHODS FOR HYPERSONIC INVISCID FLOWS	**9**
Local surface inclination methods – modified Newtonian Law – Newtonian theory – tangent wedge or tangent cone and shock expansion methods – Calculation of surface flow properties.	
UNIT 3: APPROXIMATE METHODS FOR INVISCID HYPERSONIC FLOWS	**9**
Approximate methods – hypersonic small disturbance equation and theory – thin shock layer theory – blast wave theory – entropy effects – rotational method of characteristics – hypersonic shock wave, shapes and correlations.	
UNIT 4: VISCOUS HYPERSONIC FLOW THEORY	**9**
Navier-Stokes equations – boundary layer equations for hypersonic flow – hypersonic boundary layer – hypersonic boundary layer theory and non-similar hypersonic boundary layers – hypersonic aerodynamic heating and entropy layers effects on aerodynamic heating – heat flux estimation.	

UNIT 5: VISCOUS INTERACTIONS IN HYPERSONIC FLOWS	9
Strong and weak viscous interactions – hypersonic shockwaves and boundary layer interactions – Estimation of hypersonic boundary layer transition – Role of similarity parameter for laminar viscous interactions in hypersonic viscous flow.	
TOTAL: 45 PERIODS	

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Explain shock wave and expansion wave relations of inviscid hypersonic flows.

CO2: Explain the solution methods for hypersonic inviscid flows

CO3: Analyze the hypersonic boundary layers

CO4: Explain the viscous interaction in hypersonic flows

CO5: Analyze chemical and temperature effects in hypersonic flow

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	1	1	1	-	-	-	-	1	1	1	3	2	-
CO2	3	2	1	1	2	-	-	-	-	1	1	1	3	2	-
CO3	3	3	2	-	2	-	-	-	-	1	1	2	3	1	-
CO4	3	2	1	2	3	-	-	-	-	1	1	2	3	1	-
CO5	3	2	1	1	2	-	-	-	-	1	1	1	3	2	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. AndersonJ. D., "Hypersonic and High Temperature Gas Dynamics", AIAA Education Series, 2nd Ed., 2006.

2. AndersonJ. D., "Modern Compressible Flow with Historical Perspective", TMH, 3rd Ed., 2012.

3. Parton, V. Z., "Super- and Hypersonic Aerodynamics and Heat Transfer", CRC Press, 2018.

REFERENCE BOOKS:

1. Heiser, W. H. and Pratt, D. T., "Hypersonic Air Breathing Propulsion", AIAA, 1994.

2. John T. Bertin, "Hypersonic Aerothermodynamics", AIAA Inc., Washington DC, 1994

3. T.K.S. Murthy, "Computational methods in hypersonic aerodynamics", Kluwer Academic Publishers, 1991.

WEB RESOURCES:

1. Hypersonic aerodynamics: https://archive.nptel.ac.in/courses/101/103/101103003/

AE606104- HIGH SPEED AERODYNAMICS (NPTEL)						
Course Category: Vertical 1	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

- To get insight into the basic aspects of compressible flow.
- To arrive at the shock wave and expansion wave relations.
- To get exposure on potential equation for 2-dimensionla compressible flow.
- To get knowledge on high speed flow over airfoils, wings and airplane configuration.
- To gain basic knowledge on low and high speed wind tunnels.

UNIT 1: FUNDAMENTAL ASPECTS OF COMPRESSIBLE FLOW **9**

Compressibility, Continuity, Momentum and energy equation for steady one dimensional flow-compressible Bernoulli's equation-Calorically perfect gas, Mach Number, Speed of sound, Area – Mach number – Velocity relation, Mach cone, Mach angle, One dimensional Isentropic flow through variable area duct, Static and Stagnation properties, Critical conditions, Characteristic Mach number, Area-Mach number relation, Maximum discharge velocity.

UNIT 2: WAVES IN SUPERSONIC FLOW **9**

Normal shock relations, Prandtl's relation-Hugoniot equation, Raleigh Supersonic Pitot tube equation-Moving normal shock waves, Oblique shocks, θ-β-M relation, Shock Polar, Reflection of oblique shocks, left running and right running waves-Interaction of oblique shock waves, slip line, Rayleigh flow, Fanno flow, Expansion waves, Prandtl-Meyer expansion, Maximum turning angle, Simple and non-simple regions, operating characteristics of Nozzles, under expansion, over expansion.

UNIT 3: FLOWS IN DUCTS AND WIND TUNNEL **9**

Flow in ducts Nozzle and Diffuser - Flow in Wind Tunnel - Muti dimensional Problems

UNIT 4: HIGH SPEED FLOW OVER AIRFOILS, WINGS AND AIRPLANE CONFIGURATION **9**

Critical Mach number, Drag divergence Mach number, Shock Stall, Supercritical Airfoil Sections, Transonic area rule, Swept wing, Airfoils for supersonic flows, Lift, drag, Pitching moment and Centre of pressure for supersonic profiles, Shock expansion theory, wave drag, supersonic wings, Design considerations for supersonic aircrafts

UNIT 5: CHARACTERIZATION OF HIGH SPEED FLOWS **9**

Shock-Boundary layer interaction, Wind tunnels for transonic, Supersonic and hypersonic flows, shock tube, Gun tunnels, Supersonic flow visualization, Introduction to Hypersonic Flows.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Analyze the effect of compressibility at high-speeds and to make intelligent design decisions based on this understanding.

CO2. Analyse about shock waves and expansion waves.

CO3. Calculate 2D compressible flows.

CO4. Estimate the high speed flow over airfoils and wings.

CO5. Analyze the high speed flow

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO2	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO3	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO4	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO5	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Anderson, J. D, Modern Compressible Flow: With Historical Perspective McGraw-Hill Education; 3rd edition, 2003.

2. Rathakrishnan. E, Gas Dynamics, Prentice-Hall of India Pvt., Ltd, 2008.

3. William Rees Sears (eds.)"General Theory of High Speed Aerodynamics" Princeton University Press, 1954.

REFERENCE BOOKS:

1. Oosthuizen,P.H., &Carscallen,W.E., Compressible Fluid Flow, CRC Press; 2nd edition (July22, 2013)

2. Shapiro, A. H., Dynamics and Thermodynamics of Compressible Fluid Flow, Ronald Press,1982.

3. Zucrow, M. J. and Anderson, J. D., Elements of Gas Dynamics, McGraw- Hill &Co., 1989.

4. William Hawthorne"Aerodynamics of Turbines and Compressors. (HSA-1), Princeton University Press, Volume 1"2017

WEB RESOURCES:

1. High speed aerodynamics:https://archive.nptel.ac.in/courses/101/105/101105023/

AE606105 - WIND TUNNEL TECHNIQUES (NPTEL)						
Course Category: Vertical 1	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To learn the Types of low speed Wind tunnels and non-dimensional numbers with its applications.
- To learn the Types of high speed Wind tunnels and with its calibration methods.
- To Understand the Special Wind tunnels and with its calibration methods with its design methods.
- To describe flow visualization techniques and data acquisition methods
- To understand the functions of various instruments associated with wind tunnel

UNIT 1: LOW SPEED WIND TUNNELS	**9**
Classification –non-dimensional numbers-types of similarities - Layout of open circuit and closed circuit subsonic wind tunnels – design parameters-energy ratio - HP calculations - Calibration methods.	
UNIT 2: HIGH SPEED WIND TUNNELS	**9**
Blow down, in draft and induction tunnel layouts and their design features -Transonic, and supersonic tunnels-peculiar features of these tunnels and operational difficulties - sample design calculations and calibration methods	
UNIT 3: SPECIAL WIND TUNNEL TECHNIQUES	**9**
Types of Special Wind Tunnels – Hypersonic, Gun and Shock Tunnels – Design features and calibration methods- Intake tests – store carriage and separation tests - wind tunnel model design for these tests	
UNIT 4: WIND TUNNEL INSTRUMENTATION	**9**
Instrumentation and sensors required for both steady and unsteady measurements – Force measurements using three component and six component balances – calibration of measuring instruments – error estimation and uncertainty analysis.	
UNIT 5: FLOW VISUALIZATION and NON-INTRUSIVE FLOW DIAGNOSTICS	**9**
Smoke and Tuft grid techniques – Dye injection special techniques – Oil flow visualization and PSP techniques - Optical methods of flow visualization – PIV and Laser Doppler techniques – Image processing and data deduction.	
	TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Explain the uses of various types of tunnels and its losses.

CO2. Experiment with calibration of different types of high speed tunnels.

CO3. Make use of various special tunnels and its applications.

CO4. Make use of various measurement techniques of instruments of wind tunnel.

CO5. Can use various techniques for aerodynamic data generation.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	2	1	-	-	-	-	-	-	-	-	1	2	-	-
CO2	1	3	-	-	-	-	-	-	-	-	-	1	3	1	-
CO3	1	3	1	-	-	-	-	-	-	-	-	1	3	-	-
CO4	1	3	-	-	3	-	-	-	-	-	-	1	2	1	1
CO5	1	1	1	-	-	-	-	-	-	-	-	1	3	1	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. NAL-UNI lecture series 12:" experimental aerodynamics", nalsp 98 01 april 1998.

2. Rae, W.H. and Pope, a., "Low speed wind tunnel testing", John Wiley publication, 1984.

3. Friedrich Wilhelm Riegels "Aerofoil sections: Results from wind-tunnel investigations, theoretical foundations" Butterworth & Co. (Publishers) Ltd., London, 1961.

REFERENCE BOOKS:

1. Lecture course on Advanced Flow diagnostic techniques 17-19 September 2008 NAL,Bangalore

2. Pope, A., and Goin, L., "High Speed Wind Tunnel Testing", John Wiley, 1985.

3. Rathakrishnan, E., "Instrumentation, Measurements, and Experiments in Fluids," CRC Press – Taylor & Francis, 2007.

4. Short term course on Flow visualization techniques, NAL , 2009

WEB RESOURCES:

1. Wind tunnel techniques: https://nptel.ac.in/courses/101106040

AE606106- STRUCTURAL DYNAMICS (NPTEL)

Course Category: Vertical 1	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- 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.
- Evaluate to identify, formulate and solve engineering problems. This will be accomplished behaving students' model, analyze and modify a vibratory structure order to achieve specifiedrequirements
- Introduce to structural vibrations which may affect safety and reliability of engineering

UNIT 1: SINGLE-DEGREE-OF-FREEDOM LINEAR SYST	**9**
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).	
UNIT 2: TWO-DEGREE-OF-FREEDOM SYSTE	**9**
Introduction, Equations of Motion for Forced Vibration, Free Vibration Analysis of an Undammed System, Torsional System, Coordinate Coupling and Principal Coordinates, Forced-Vibration Analysis, Semi definite Systems, Self-Excitation and Stability Analysis, Transfer- Function Approach, Solutions Using Laplace Transform, Solutions Using Frequency Transfer Function.	
UNIT 3 MULTI-DEGREE-OF-FREEDOM LINEAR SYST	**9**
Matrix formulation, stiffness and flexibility influence coefficients; Eigen value problem; normal modes and their properties; Free and forced vibration by Modal analysis; Method of matrix inversion; Torsional vibrations of multi- rotor systems and geared systems; Discrete- Time system.	
UNIT 4: DYNAMICS OF CONTINUOUS ELASTIC BO	**9**
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 m	
UNIT 5: NTRODUCTION TO AEROELASTICITY	**9**
tatic Aeroelasticity; Typical Section Model of an Airfoil: Typical Section Model with Control Surface, Typical Section Model—Nonlinear Effects. One Dimensional Aeroelastic Model of Airfoils: Beam-Rod Representation of Large Aspect Ratio Wing, Eigenvalue and Eigen function Approach, Galerkin's Method. Dynamic Aeroelasticity; Hamilton's Principle: Single Particle, Many Particles, Continuous Body, Potential Energy, Non potential Forces, Lagrange's Equations.	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Explain the concepts of the equation of motion of free vibration and its response for determining the nature of single degree of freed.	
CO2: Demonstrate the response of step function, periodic excitation (Fourier series and transform, Laplace transform) of Single DOF for determining the freely vibrating of a body	
CO3: Construct the equation of motion of free vibration for the design of the analysis of the spring-mass system.	
CO4: Apply the various equations of forced vibration for determining the frequency of the body	
CO5: Analysis the torsional vibrations of rotor and geared systems for determining the DOF of the vibrating system.	
CO'S PO'S&PSO'S MAPPING	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	2	2	-	-	-	-	-	1	-	2	-	3	3
CO2	3	3	-	2	1	-	-	-	-	1	-	2	-	2	2
CO3	3	2	2	-	2	1	1	-	-	-	1	1	1	2	1
CO4	3	2	1	-	1	-	-	2	-	-	1	1	2	1	1
CO5	3	3	2	1	2	1	-	2	1	1	2	2	2	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Bismarck-Nasr, M.N., "Structural Dynamics in Aeronautical Engineering", AIAA Education Series, 2nd Edition, 1999.

2. Rao, S.S., "Mechanical Vibrations", Prentice-Hall, 5 th Edition, 20.

3. Earl H. Dowell, "A Modern Course in Aeroelasticity" Volume 217, Duke University, Durham, NC, USA.

REFERENCE BOOKS:

1 http://www.gregorypaulblog.com/structural-dynamics-in-aeronautical-engineering-aiaa-education- series.pdf

2. https://aerocastle.files.wordpress.com/2012/10/mechanical_vibrations_5th-edition_s-s-rao.pd.

3. Leissa, A.W., Vibration of continuous system, The McGraw-Hill Company, 2 nd Edition, 2011

4 Inman, D.J., Vibration Engineering, Prentice Hall Int., Inc., 3 rd Edition, 2001

WEB RESOURCES:

1http://ase.sbu.ac.ir/FA/Staff/abbasrahi/Lists/Dars/Attachments/11/Vibrations%20of%20Continuous%20Systems.pdf

AE606107- AEROSPACE PROPULSION (NPTEL)					
Course Category: Vertical 1	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To impart knowledge on the basic concepts of space propulsion.
- To learn about the physics of ionized gases
- To get familiarize with the types of nuclear rockets and the basic concepts of nuclear propulsion systems.
- To study about the radioisotope propulsion.
- To realise the importance of advanced space propulsion concepts.

UNIT 1: INTRODUCTION TO SPACE PROPULSIONSYSTEMS **9**

Historical outline, Scramjet Propulsion-Scramjet Inlets; Scramjet Performance, Chemical rocket Propulsion-

Tri-propellants; Metalized Propellants; Free Radical Propulsion, Electric Propulsion, Micro propulsion - Micro Propulsion Requirements, MEMS and MEMS- Hybrid Propulsion Systems..	
UNIT 2: BASIC CONCEPTS OF IONIZED GASES	**9**
Electromagnetic theory: electric charges and fields, currents, and magnetic fields, and applications to ionized gases. Atomic structure of gases - Ionization processes - Particle collisions in an ionized gas – Electrical conductivity of an ionized gas - Kinetic Theory, Introduction to plasma physics- Electrode phenomena.	
UNIT 3: NUCLEAR ROCKET PROPULSION	**9**
Nuclear Rocket Engine Design and Performance, Types of Nuclear Rockets, Overall Engine Design, Nuclear Rocket Performance, Component Design, Nuclear Rocket Reactors, General Design Considerations, Reactor Core Materials, Thermal Design, Mechanical Design, Nuclear Design, Shielding, Nuclear Rocket Nozzles, General Design Considerations, Heat-Transfer Analysis, Over- all Problem, Hot-Gas Boundary, Cold-Gas Boundary.	
UNIT 4: RADIOISOTOPE PROPULSION	**9**
Alternative Approaches, Direct Recoil Method, Thermal Heating Method, Basic Thruster Configurations, Propulsion System and Upper Stage, Relative Mission Capabilities, Primary Propulsion, Auxiliary Propulsion, Thruster Technology, Design Criteria, Performance, Safety, Heat Source Development, Radioisotope Fuel, Capsule Technology, General Considerations, Thermal Design, Fabrication and Non-Destructive Testing Techniques, Pressure Containment, Heat Source Simulation, Oxidation and Corrosion of Encapsulating Materials, Nozzle Performance.	
UNIT 5: ADVANCED SPACE PROPULSION CONCEPTS	**9**
Introduction, General Consideration for Propulsion in Space, Power Supply, Propellant Storage and Handling Facilities, Electrostatic and Electromagnetic Thrusters, Advanced Electric Propulsion Systems for Space Vehicles, Sputtering, A Thrust Generation Mechanism, Sputtering Phenomena, Possible Performance of Sputtering Thrusters, Energy Efficiency of the Sputtering Process, Analyses of an Elementary Mission with Different Electric Thrusters, General Consideration, Performance Formula for Electric Thrusters, Optimization with Electric Thrusters.	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Have knowledge on the basics and classification of space propulsion.	
CO2: Comprehend the physics of ionized gases, their theories and particle collisions.	
CO3: Demonstrate the working, types and performance of nuclear rockets with their design considerations.	
CO4: Learn the basics of radioisotope propulsion with their performance studies.	
CO5: Have knowledge on advanced methods of space propulsion systems with new thrus generation mechanisms	
CO'S PO'S&PSO'S MAPPING	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	1	-	-	-	1	-	1	2	1	-
CO2	3	2	1	1	2	1	-	-	-	1	-	1	2	1	
CO3	3	2	1	1	2	1	-	-	-	1	-	1	2	1	1
CO4	3	2	1	1	2	1	-	-	-	1	-	1	2	1	1
CO5	2	1	1	-	1	1	-	-	-	-	-	1	2	1	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Czysz, Paul A., Bruno, Claudio, Chudoba, Bernd "Future Spacecraft Propulsion Systems and Integration", Springer, Praxis Publishing Ltd, 2018

2. George W. Sutton, "Engineering Magneto hydrodynamics", Dover Publications Inc., New York, 2006.

3. Timoshenko, S.P, and Goodier, T.N., Theory of Elasticity, McGraw – Hill Ltd., Tokyo, 1990.

REFERENCE BOOKS:

1. Robert G. Jahn, "Physics of Electric Propulsion", McGraw-Hill Series, New York, 1968.

2. William J. Emrich, "Principles of Nuclear Rocket Propulsion" Elsevier Science, 2016.

WEB RESOURCES:

1AEROSPACE PROPULSION : https://nptel.ac.in/courses/105105177

AE606108 - GAS DYNAMICS AND JET PROPULSION

Course Category: Vertical 1	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To analysis the phenomenon of shock waves and its effect on flow. To gain some
- To analysis the basic difference between incompressible and compressible flow. basic knowledge about jet propulsion and Rocket Propulsion..

UNIT 1: BASIC CONCEPTS AND ISENTROPIC FLOWS **9**

Energy and momentum equations of compressible fluid flows – Stagnation states, Mach waves and Mach cone – Effect of Mach number on compressibility – Isentropic flow through variable ducts – Nozzle and Diffuse.

UNIT 2: FLOW THROUGH DUCTS **9**

Flows through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow) – variation of flow properties

UNIT 3: NORMAL AND OBLIQUE SHOC **9**

Governing equations – Variation of flow parameters across the normal and oblique shocks – Prandtl – Meyer relations – Application

UNIT 4: JET PROPULSION	9
Theory of jet propulsion – Thrust equation – Thrust power and propulsive efficiency – Operating principle, cycle analysis and use of stagnation state performance of ram jet, turbojet, turbofan and turbo prop engines	
UNIT 5: SPACE PROPULSION	**9**
Types of rocket engines – Propellants-feeding systems – Ignition and combustion – Theory of rocket propulsion – Performance study – Staging – Terminal and characteristic velocity – Applications – space flight	
TOTAL: 45 PERIODS	

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Apply the concept of compressible flows in variable area ducts.

CO2: Apply the concept of compressible flows in constant area ducts

CO3: examine the effect of compression and expansion waves in compressible flow

CO4: use the concept of gas dynamics in Jet Propulsion

CO5: apply the concept of gas dynamics in Space Propulsion..

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	3	-	-	-	-	-	-	-	-	2	2	-	-
CO2	-	3	-	2	-	-	-	-	2	-	-	-	-	2	1
CO3	2	-	3	-	-	-	-	-	-	-	-	2	2	-	-
CO4	2	-	-	2	3	-	-	-	-	-	-	-	-	-	-
CO5	-	3	-	-	-	-	-	-	-	-	-	-	-	-	

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Anderson, J.D., "Modern Compressible flow", 3 rd Edition, McGraw Hill, 201

2. Yahya, S.M. "Fundamentals of Compressible Flow", New Age International (P) Limited, New Delhi, 2002

REFERENCE BOOKS:

1. Cohen. H., G.E.C. Rogers and Saravanamutto, "Gas Turbine Theory", Longman Group Ltd.,1980

2. Ganesan. V., "Gas Turbines", Tata McGraw Hill Publishing Co., New Delhi, 2010.

3. Shapiro. A.H.," Dynamics and Thermodynamics of Compressible fluid Flow", John wiley, New York, 1953

WEB RESOURCES:

1. jet propulsion - https://nptel.ac.in/courses/101104005

Vertical-2

AEROSPACE STRUCTURES

CURRICULUM

S. No.	Course Code	Course Title	Classification		L	T	P	C
1	AE606201	Fatigue and fracture mechanism (NPTEL)	PE	Theory	3	0	0	3
2	AE606202	Experimental stress analysis (NPTEL)	PE	Theory	3	0	0	3
3	AE606203	Aerospace materials	PE	Theory	3	0	0	3
4	AE606204	Additive manufacturing (NPTEL)	PE	Theory	3	0	0	3
5	AE606205	Non-destructive testing and evaluation (NPTEL)	PE	Theory	3	0	0	3
6	AE606206	Aerospace manufacturing technology	PE	Theory	3	0	0	3
7	AE606207	Aircraft Stress Analysis	PE	Theory	3	0	0	3
8	AE606208	Nano materials and aero applications	PE	Theory	3	0	0	3
9	AE606209	Aircraft High temperature Materials	PE	Theory	3	0	0	3

AE606201- FATIGUE AND FRACTURE MECHANISM						
Course Category: Vertical 2	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

•To impart knowledge in structural integrity in the context of fatigue failure.

•To gain knowledge in statistical aspects of fatigue behaviour and R-S-N curve.

•To impart knowledge in physical aspects of fatigue.

•To familiarize the student with theoretical fracture mechanics and make competent to carry out simple fracture analysis procedures

•To enable the student to appreciate the different aspects of fatigue testing methods

UNIT 1: FATIGUE OF STRUCTURES	**9**

S.N. curves - Endurance limits - Effect of mean stress, Goodman, Gerber and Soderberg relations and diagrams - Notches and stress concentrations - Neuber's stress concentration factors - Plastic stress concentration factors - Notched S.N. curves – Fatigue of composite materials.

UNIT 2: STATISTICAL ASPECTS OF FATIGUE BEHAVIOUR	**9**

Low cycle and high cycle fatigue - Coffin - Manson's relation - Transition life - cyclic strain hardening and softening - Analysis of load histories - Cycle counting techniques -Cumulative damage - Miner's theory - Other theories - Reliability study on fatigue (R-S-N curve).

UNIT 3: PHYSICAL ASPECTS OF FATIGUE	**9**

Phase in fatigue life - Crack initiation - Crack growth - Final Fracture - Dislocations - fatigue fracture surfaces.

UNIT 4: FRACTURE MECHANICS	**9**

Modes of failure - Potential energy and surface energy - Griffith's theory - Irwin - Orwin extension of Griffith's theory to ductile materials - stress analysis of "cracked bodies - Effect of thickness on fracture toughness" - stress intensity factors for typical 'geometries.

UNIT 5: FATIGUE DESIGN AND TESTING	**9**

Safe life and Fail-safe design philosophies - Importance of Fracture Mechanics in aerospace structures

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Develop a solid foundation in the theory, concepts and principles of fracture mechanics,

CO2: Able to use these solutions to guide a corresponding design, manufacture, or failure analysis and reliability on fatigue.

CO3: Ability to investigate the life of a structure under dynamic loading conditions.

CO4: Knowledge of fracture mechanics approach applicable to homogeneous and heterogeneous materials

CO5: Knowledge of probalistic approach and development of mathematical models for life prediction of

structures and knowledge of safe life and fail safe design.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	2	2	2	-	-	-	-	1	-	2	-	3	3
CO2	3	3	1	2	1	-	-	-	-	1	-	2	-	3	2
CO3	3	2	2	1	2	1	1	-	-	-	1	1	2	2	1
CO4	3	2	1	-	1	-	-	2	-	-	1	1	2	1	1
CO5	3	3	2	1	2	1	-	2	1	1	2	2	2	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Barrois W, Ripely, E.L., "Fatigue of aircraft structure," Pergamon press. Oxford, 1983.

2. Prashant Kumar – Elements of fracture mechanics" Tata McGraw Hill Education Private Limited ,2009

3. Jean Lemaitre, Rodrigue Desmorat "Engineering damage mechanics: ductile, creep, fatigue and brittle failures " Springer, New York, 2005.

4. Yung-Li Lee, Jwo Pan, Richard Hathaway, Mark Barkey "Fatigue Testing and Analysis. Theory and Practice" Butterworth-Heinemann, 2004.

REFERENCE BOOKS:

1 Kare Hellan ,'Introduction to Fracture Mechanics', McGraw Hill, Singapore,1985

2. Knott, J.F., "Fundamentals of Fracture Mechanics," - Buterworth & Co., Ltd., London, 1983.

3. Sih C.G., "Mechanics of fracture." Vol - I, Sijthoff and w Noordhoff International Publishing Co., Netherlands, 1989.

WEB RESOURCES:

1.Fatigue and fracture mechanism: https://archive.nptel.ac.in/courses/113/105/113105106/

AE606202 - EXPERIMENTAL STRESS ANALYSIS						
Course Category: Vertical 2	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

- To familiarize with different types of strain gauges used.
- To analysis the concept of photo elasticity and methods for stress analysis.
- To familiarize with the different NDT techniques.

UNIT 1: OVERVIEW AND MEASUREMENTS	**9**

Overview of Experimental stress analysis - Physical Principle of strain gauges, Principles of measurements, Accuracy, Sensitivity and range of measurements. Extensometers and their uses, Advantages and disadvantages.

UNIT 2: TRANSMISSION PHOTO ELASTICITY	**9**

Ordinary and extraordinary rays - Light ellipse - Retartation plates - plane polariscope - calibration of photo elastic materials - Fringe thinning methodologies.

UNIT 3: PHOTOELASTICITY	**9**

Two dimensional photo elasticity, Concept of light – photo elastic effects, stress optic law, Interpretation of fringe pattern, Photo elastic materials - Three dimensional photo elasticity.

UNIT 4: PHOTOELASTIC COATING AND MOIRE METHODS	**9**

Introduction to photoelastic coating - Correction factor for photo elastic coating - Moire techniques, Analysis of brittle coating.

UNIT 5: STRAIN GAUGES	**9**

Introduction to strain gauges - Strain sensitivity - Performance of strain gauge system - Temperature compensation - strain gauge selection - Calibration-Wheatstone bridge

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Knowledge of stress and strain measurements in loaded components.

CO2: Acquiring information's the usage of strain gauges and photo elastic techniques of measurement.

CO3: Formulate and solve general three dimensional problems of stress-strain analysis especially fundamental problems of elasticity

CO4: Analyze the strain gauge data under various loading condition by using gauge rosette method.

CO5: Experimentally evaluate the location and size of defect in solid and composite materials by using various Non-destructive Testing methods.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	3	2	-	-	-	-	-	-	-	-	2	-	-
CO2	3	3	3	2	-	1	-	1	1	1	1	2	1	-	
CO3	3	3	2	2	2	-	1	-	-	-	1	-	2	1	1
CO4	3	3	2	2	2	1	1	-	1	-	-	1	2	-	1
CO5	3	3	3	2	2	1	1	-	-	1	1	1	2	1	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Srinath, L.S., Raghava, M.R., Lingaiah, K., Garagesha, G., Pant B., and Ramachandra, K., "Experimental Stress Analysis", Tata McGraw-Hill, New Delhi, 2016.

2. Sadhu singh "Experimental stress analysis" Khanna Publishers 2017.

3. Pollock A.A., "Acoustic Emission in Acoustics and Vibration Progress", Ed. Stephens R.W.B., Chapman and Hall, 2016.

REFERENCE BOOKS:

1. Dally, J.W., and Riley, W.F., "Experimental Stress Analysis", McGraw-Hill Inc., NewYork, IV edition 2005,

2. Hetyenyi, M., "Hand book of Experimental Stress Analysis", John Wiley and Sons Inc.,New York, 2014.

3. U. C. Jindal "Experimental Stress Analysis" Pearson Education, 2014.

4. Karthik Selva Kumar Karuppasamy, Balaji P.S "Applications and Techniques for Experimental Stress Analysis" Engineering Science Reference, 2019.

WEB RESOURCES:

1.Experimental stress analysis: https://archive.nptel.ac.in/courses/112/106/112106068/

AE606203- AEROSPACE MATERIALS

Course Category: Vertical 2	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Different materials with their properties
- Different materials with their mechanical behavior
- Various Heat Treatment processes of aircraft metals and alloys
- Applications of Aluminum alloys and Composites
- Selection of Aerospace Materials

UNIT 1: MATERIAL REQUIREMENTS FOR AEROSPACE STRUCTURES AND ENGINES	**9**
Introduction, Fixed-wing aircraft structures - Helicopter structures - Space shuttle structures - Materials used in jet engines.	
UNIT 2: MECHANICAL BEHAVIOR OF ENGINEERING MATERIALS	**9**
Linear and non-linear elastic properties, Mechanism of elastic and inelastic action. Yielding, strain hardening, true stress, true strain, Failure of materials – fracture, Fatigue, creep - Bauchinger's Effect, Notch Effect, Testing and flaw detection of materials and components.	
UNIT 3: HEAT TREATMENT OF ALLOYS AND CORROSION	**9**
Introduction to heat treatment process, Heat treatment of carbon steel - Heat treatment of - aluminium alloys, magnesium alloys - Heat treatment of titanium alloys - Classification and Effect of corrosion Aircraft, Corrosion - Protection, Resistant materials.	
UNIT 4: ALUMINUM ALLOYS AND COMPOSITES	**9**
Introduction - Physical Metallurgy - Cast Aluminium Alloys and Wrought Aluminium Alloys - Aerospace Applications – Plastics and Rubber - Introduction to FRP, Glass and Carbon Composites - Fibers and Resins Characteristics and applications - Failure theories for isotropic and anisotropic materials.	
UNIT 5 SELECTION OF MATERIALS FOR AIRCRAFT AND ROCKETS	**9**
Classification of aircraft materials - Materials used for aircraft components - Application of Composite materials - Super alloys - Emerging trends in Aerospace materials, Introduction to smart materials, light weight material for MAV/UAV.	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Formulate and perform classical solutions of aeroelastic problems.	
CO2: Calculate divergence of a lifting surface in the aerospace vehicles.	
CO3: Formulate aeroelastic equations of motion and use them to derive fundamental relations for aeroelastic analysis.	
CO4: Analyze the static aeroelastic instabilities such as divergence, control surface reversal and flutter	
CO5: Analyze the aeroelastic problems in civil and mechanical engineering.	

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	-	3	-	-	-	-	-	-	-	-	2	2	-	-
CO2	-	3	-	2	-	-	-	-	2	-	-	-	-	2	1
CO3	2	-	3	-	-	-	-	-	-	-	-	2	2	-	-
CO4	2	-	-	2	3	-	-	-	-	-	-	-	-	-	-
CO5	-	3	-	-	-	-	-	-	-	-	-	-	-	-	

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Adrian P. Mouritz, "Introduction to aerospace materials" Woodhead Publishing Limited, 2012.
2. Titterton, G., "Aircraft Materials and Processes ", Fifth Edition, Pitman Publishing Co., 1995.
3. Krishnadas Nair, C.G., "Handbook of Aircraft Materials ", Interline Publishing, 1993.
4. Balram Gupta, "Aerospace Materials ", Vol. I, Vol. II and Vol. III, S.Chand & Company Ltd., New Delhi -1996.

REFERENCE BOOKS:

1. Brian Cantor, Hazel Assender and Patrick Grant "Series in Materials Science and Engineering Aerospace Materials", Institute of Physics Publishing Bristol and Philadelphia (IOP) Publishing Ltd 2001.
2. Martin, J.W., "Engineering Materials, Their Properties, and Applications ", Wykedham Publications (London) Ltd., 1987.

WEB RESOURCES:

1.Aerospace materials - https://mrcet.com/downloads/digital_notes/AE/II%20Year/Aerospace%20Materials%20and%20Composites.pdf

AE606204- ADDITIVE MANUFACTURING

Course Category: Vertical 2	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To introduce the development of Additive Manufacturing (AM), various business opportunities and applications
- To familiarize various software tools, processes and techniques to create physical objects that satisfy product development / prototyping requirements, using AM.
- To be acquainted with vat polymerization and direct energy deposition processes
- To be familiar with powder bed fusion and material extrusion processes.

- To gain knowledge on applications of binder jetting, material jetting and sheet lamination processes

UNIT 1: INTRODUCTION TO ADDITIVE MANUFACTURING	**9**

Overview - Need - Development of Additive Manufacturing (AM) Technology: Rapid Prototyping- Rapid Tooling - Rapid Manufacturing - Additive Manufacturing. AM Process Chain- ASTM/ISO 52900 Classification - Benefits. Applications: Building Printing - Bio Printing - Food Printing- Electronics Printing. Business Opportunities and Future Directions – Case studies: Automobile, Aerospace, Healthcare.

UNIT 2: DESIGN FOR ADDITIVE MANUFACTURING (DFAM)	**9**

Concepts and Objectives - AM Unique Capabilities - Part Consolidation – Topology Optimization- Generative design - Lattice Structures - Multi-Material Parts and Graded Materials - Data Processing: CAD Model Preparation - AM File formats: STL-Problems with STL- AMF Design for Part Quality Improvement: Part Orientation - Support Structure - Slicing - Tool Path Generation – Design rules for Extrusion based AM.

UNIT 3: VAT POLYMERIZATION AND DIRECTED ENERGY DEPOSITION	**9**

Photo polymerization: Stereolithography Apparatus (SLA)- Materials -Process – top down and bottom up approach - Advantages - Limitations - Applications. Digital Light Processing (DLP) - Process - Advantages - Applications. Continuous Liquid Interface Production (CLIP) Technology. Directed Energy Deposition: Laser Engineered Net Shaping (LENS)- Process - Material Delivery - Materials -Benefits -Applications.

UNIT 4: POWDER BED FUSION AND MATERIAL EXTRUSION	**9**

Powder Bed Fusion: Selective Laser Sintering (SLS): Process - Powder Fusion Mechanism - Materials and Application. Selective Laser Melting (SLM), Electron Beam Melting (EBM): Materials - Process - Advantages and Applications. Material Extrusion: Fused Deposition Modeling (FDM)- Process-Materials - Applications and Limitations.

UNIT 5: OTHER ADDITIVE MANUFACTURING PROCESSES	**9**

Binder Jetting: Three-Dimensional Printing - Materials - Process - Benefits- Limitations - Applications. Material Jetting: Multijet Modeling- Materials - Process - Benefits - Applications. Sheet Lamination: Laminated Object Manufacturing (LOM)- Basic Principle- Mechanism: Gluing or Adhesive Bonding - Thermal Bonding- Materials-Application and Limitation.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Recognize the development of AM technology and how AM technology propagated into various businesses and developing opportunities..

CO2: Acquire knowledge on process of transforming a concept into the final product in AM technology.

CO3: Elaborate the vat polymerization and direct energy deposition processes and its applications

CO4: Acquire knowledge on process and applications of powder bed fusion and material extrusion.

CO5: Evaluate the advantages, limitations, applications of binder jetting, material jetting and sheet lamination processes.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	3	2	-	-	-	-	-	-	-	-	2	-	-
CO2	3	3	3	2	-	-	-	-	-	-	-	2	-	-	
CO3	3	2	1	2	-	-	-	-	1	1	1	1	2	2	1
CO4	3	2	1	2	1	1	1	-	-	-	-	1	2	-	1
CO5	3	3	3	2	1	1	1	-	1	1	1	1	2	2	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Andreas Gebhardt, "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing", Hanser Gardner Publication, Cincinnati., Ohio, 2011, ISBN :9783446425521.

2. Andreas Gebhardt and Jan-Steffen Hötter "Additive Manufacturing: 3D Printing for Prototyping and Manufacturing", Hanser publications, United States, 2015, ISBN: 978-1- 56990-582-1.

REFERENCE BOOKS:

1. Amit Bandyopadhyay and Susmita Bose, "Additive Manufacturing", 1st Edition, CRC Press., United States, 2015, ISBN

2. Liou, L.W. and Liou, F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press., United States, 2011, ISBN: 9780849334092.

3. Amit Bandyopadhyay and Susmita Bose, "Additive Manufacturing", 1st Edition, CRC Press., United States, 2015, ISBN-13: 978-1482223590.

WEB RESOURCES:

1.Additive manufacturing: https://home.iitk.ac.in/~nsinha/Additive_Manufacturing%20I.pdf

AE606205 - NONDESTRUCTIVE TESTING AND EVALUATION

Course Category: Vertical 2	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To acquaint the students with the overview of NDT
- To elaborate the concept and procedure for liquid and magnetic penetrant testing and evaluate through practical study
- To introduce the concept and procedure for radiograph testing methods and evaluate through practical study
- To brief the concepts and procedures for Ultrasonic testing methods and their applications

- To impart knowledge in other methods of NDT and electrical method with case study

UNIT 1: INTRODUCTION TO NONDESTRUCTIVE TESTING	9

NDT Versus Mechanical testing - Overview of the Non Destructive Testing Methods for the detection of manufacturing defects as well as material characterisation. Relative merits and limitations, Various physical characteristics of materials and their applications in NDT- Visual
inspection – Unaided and aided.

UNIT 2: SURFACE NDE METHODS	9

Liquid Penetrant Testing - Principles, types and properties of liquid penetrants, developers, advantages and limitations of various methods, Testing Procedure, Interpretation of results. Magnetic Particle Testing- Theory of magnetism, inspection materials Magnetisation methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism.

UNIT 3: THERMOGRAPHY AND EDDY CURRENT TESTING (ET)	9

Thermography- Principles, Contact and noncontact inspection methods, Techniques for applying liquid crystals, Advantages and limitation - infrared radiation and infrared detectors, Instrumentations and methods, applications. Eddy Current Testing-Generation of eddy currents, Properties of eddy currents, Eddy current sensing elements, Probes, Instrumentation, Types of arrangement, Applications, advantages, Limitations, Interpretation/Evaluation.

UNIT 4: ULTRASONIC TESTING (UT) AND ACOUSTIC EMISSION (AE)	9

Ultrasonic Testing-Principle, Transducers, transmission and pulse-echo method, straight beam and angle beam, instrumentation, data representation, A/Scan, B-scan, C-scan. Phased Array Ultrasound, Time of Flight Diffraction. Acoustic Emission Technique – Principle, AE parameters, Applications

UNIT 5: RADIOGRAPHY (RT)	9

Principle, interaction of X-Ray with matter, imaging, film and film less techniques, types and use of filters and screens, geometric factors, Inverse square, law, characteristics of films - graininess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence. Fluoroscopy-Xero-Radiography, Computed Radiography,
Computed Tomography

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Discuss the basics of NDT and its industrial standards.

CO2: Acquire knowledge on the concept and procedure for liquid and magnetic penetrant testing.

CO3: Interpret the given mechanical components to inspect using radiograph testing methods techniques

CO4: Apply ultrasonic techniques based on materials and its application.

CO5: Describe the applications of electrical and other NDT methods.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	2	1	-	-	-	-	-	-	-	-	-	2	-	-
CO2	1	3	-	-	3	-	-	-	-	-	-	-	3	1	-
CO3	1	3	1	1	1	-	-	-	-	-	-	-	3	1	-
CO4	1	2	-	2	3	-	-	-	-	-	-	-	2	-	-
CO5	1	1	1	-	-	-	-	-	-	-	-	-	3	1	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Baldev Raj, T.Jayakumar, M.Thavasimuthu "Practical Non-Destructive Testing", Narosa Publishing House, 2014.

2. Ravi Prakash, "Non-Destructive Testing Techniques", 1st revised edition, New Age International Publishers, 2010

REFERENCE BOOKS:

1. "Non-destructive Testing Handbook", Vol. 1-10, 3rd Edition, American Society for Non Destructive Testing. 2010. ISBN: 978-1-57117-186-3.

2. Hellier C., "Handbook of Non-destructive Evaluation", 1st edition, McGraw-Hill Professional., United States, 2001. ISBN: 0070281211, 978-0070281219.

3. Paipetis A.S, Matikas T. E., and Aggelis D. G., "Emerging Technologies in Non- Destructive Testing",1st edition, CRC Press., United States, 2012. ISBN :9780415621311.

4. Ravi Prakash, "Non-destructive Testing Techniques", 1st Edition, New Age Science., India, 2009. ISBN: 1906574065, 978-1906574062.

5. Charles, J. Hellier," Handbook of Nondestructive evaluation", McGraw Hill, New York 2001.

6. Paul E Mix, "Introduction to Non-destructive testing: a training guide", Wiley, 2nd Edition New Jersey, 2005

WEB RESOURCES:

1. Non Destructive Testing: https://web.itu.edu.tr/~arana/ndt.pdf

AE606206 - AEROSPACE MANUFACTURING TECHNOLOGY						
Course Category: Vertical 2	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

- To make the student aware of various production technologies generally involved in air craft manufacturing
- Understand the Concepts of welding and casting Technology.
- Understand the machining operations.
- Understand the unconventional machining processes.
- Understand the Forming of metals and Sheet metal.
- Understand the operations aircraft metals heat treatment and surface finishing

UNIT 1: CASTING AND WELDING	**9**

General principles of various Casting Processes - Sand casting, die-casting, centrifugal casting, investment casting and shell molding types - Principles and equipment used in arc welding, gas welding, resistance welding - Laser welding, Electron Beam welding - Soldering and brazing techniques.

UNIT 2: MACHINING OPERATIONS	**9**

General Principles of working of lathe, types of lathe and commonly performed operation in lathe - General Principles of working, types and operation of grinding and drilling machines - General Principles of working, types and operation of Shaper and milling machines - General Principles of working, types and operation of CNC Machining.

UNIT 3: UNCONVENTIONAL MACHINING PROCESSES	**9**

Principles of working and Application of Abrasive Jet Machining, Ultrasonic Machining - Principles of working and Application of Electric Discharge Machining, Electrochemical Machining, Chemical Machining - Principles of working and Application of LASER Beam Machining, Electron Beam Machining, Plasma Arc Machining

UNIT 4: FORMING OPERATIONS	**9**

Forming of metals – Forging of metals, Rolling, Extrusion, and Drawing - Sheet metal operations-shearing, punching, super plastic forming, diffusion bonding, and different operations in bending - Riveting types and techniques used in aerospace industry.

UNIT 5: HEAT TREATMENT AND SURFACE FINISHING	**9**

Heat treatment process of aluminium alloys, titanium alloys, Steels - Case hardening, internal stresses and the stress relieving procedures - Surface Finishing operations - protective treatment for aluminium alloys, steels, anodizing of titanium alloys, organic coating, and thermal spray coatings

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Acquire an overview of electric vehicles and their importance in automotive.

CO2. Discuss the characteristics and the selection of traction motor.

CO3. Comprehend the vehicle-to-vehicle and autonomous technology.

CO4. Explain the networking of various modules in automotive systems, communication protocols and diagnostics of the sub systems.

CO5. Be familiar with on-board diagnostics systems.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO2	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO3	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO4	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO5	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Keshu S.C, Ganapathy K.K, "Aircraft production technique' Interline Publishing House, Bangalore 1993.

2. Dr. P C Sharma, "A Text book of Production Technology" S. CHAND and company Pvt. Ltd. New Delhi, Eighth edition 2014.

3. R.K. Jain "Production technology" - Khanna Publishers New Delhi 2002.

4. Beddoes, J. and Bibby, M. J., Principles of Metal Manufacturing Processes, ButterworthHeinemann (1999

REFERENCE BOOKS:

1. O.P.Khanna and lal "Production technology" M.Dhanpat rai publications, New Delhi 1997.

2. Campbell, F. C., Manufacturing Technology for Aerospace Structural Materials, Elsevier (2006).

3. Ghosh, A. and Mallik, A. K., Manufacturing Science, Affiliated East West Press (2010).

4. Abbaschian, R., Abbaschian, L., and Reed-Hill, R. E., Physical Metallurgy Principles, 4th ed., Cengage Learning (2008).

WEB RESOURCES:

1. Aircraft Manufacturing Technology: https://www.youtube.com/watch?v=MXZpSLQ0Yfw

AE606207 - AIRCRAFT STRESS ANALYSIS						
Course Category: Vertical 8	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To study the behavior of various aircraft structural components under different types of loads
- To introduce to practical stress analysis, using real structural problems to illustrate the fundamental principles and practical techniques.

UNIT 1: LOADING IN AIRCRAFTS	**9**
Loading Requirements, Loads due to maneuver and gusts, Load distribution, Undercarriage and crash cases. Loading and analysis of aircraft wing, fuselage, and tail unit.	
UNIT 2: STRESSING IN AIRCRAFTS	**9**
Stressing, The place of stress calculations in aircraft design and production, Strength and stiffness requirements, Factors, Material properties, Composites, Fatigue and fracture.	
UNIT 3: DETAILED STRESSING METHODS	**9**
Detail Stressing Methods, In-plane and bending stresses, Section properties, Torsion, Rivets and bolts, Lugs, Yielding and form factors, Composite properties and stress analysis. Use of V-N diagram for sizing the aircraft wing, fuselage, and tail unit.	
UNIT 4: BUCKLING IN AIRCRAFTS	**9**
Buckling, Formulae for struts, effects of yielding, Torsional and local instability, Buckling of stiffened panels in compression and shear, post buckled behavior, Imperfection sensitivity.	
UNIT 5: AIRCRAFT STRUCTURAL ANALYSIS	**9**
Aircraft Structures, Reinforced shells under bending and torsion, Fuselage frames, Rib analysis, Finite element analysis, Safe life and damage tolerant analysis.	
	TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Analyze the aircraft wing, tail, and fuselage

CO2. Identify the stress and other factors.

CO3. Understand the various stress methods.

CO4. Knowledge on buckling in aircraft.

CO5. Analyse the aircraft structures.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	3	3	-	-	-	2	-	-	2	1	1	1
CO2	3	3	3	3	3	-	-	-	2	-	-	3	1	1	1
CO3	2	3	3	2	3	-	-	-	2	-	-	3	1	1	1
CO4	2	3	3	3	2	-	-	-	2	-	-	3	1	1	1
CO5	3	2	3	2	3	-	-	-	2	-	-	3	1	1	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Howard D Curtis, 'Fundamentals of Aircraft Structural Analysis', WCB-McGraw Hill, 1997

2**.** Bruhn. E.H., 'Analysis and Design of Flight Vehicles Structures', Tri-state off-set company, USA, 1985

3. T.H.G. Megson - Introduction to aircraft structural analysis (Butterworth-Heinemann, London, UK) 2013.

REFERENCE BOOKS:

1. Rivello, R.M., Theory and Analysis of Flight Structures, McGraw Hill, 1993.

2. Peery, D.J., and Azar, J.J., Aircraft Structures, 2nd edition, McGraw – Hill, N.Y., 1999

3. D.R.Adams - Aircraft stress analysis (Pitman & Sons, New York, USA) 2007.

4. James-D. Haddon - Introduction to aeronautical engineering (Pitman & Sons, New York, USA) 2006.

WEB RESOURCES:

1. Aircraft Stress Analysis: https://www.stressebook.com/stress-analysis-course/

AE606208- NANO MATERIALS AND AERO APPLICATIONS						
Course Category: Vertical 2	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To impart knowledge of the hydraulic and pneumatic systems components
- To study about synthesis of nano materials and nano structure
- To impart knowledge about nano composites and its application

UNIT 1: INTRODUCTION TO NANO TECHNOLOGY	**9**
General definition and size effects–important nano structured materials and nano particles- importance of nano materials- Size effect on thermal, electrical, electronic, mechanical, optical and magnetic properties of nanomaterials- surface area - band gap energy and applications. Photochemistry and Electrochemistry of nanomaterials –Ionic properties of nanomaterials- Nano catalysis.	
UNIT 2: SYNTHESIS OF NANOMATERIALS	**9**
Bottom up and Top-down approach for obtaining nano materials - Precipitation methods – sol gel technique – high energy ball milling, CVD and PVD methods, gas phase condensation, magnetron sputtering and laser deposition methods – laser ablation, sputtering.	
UNIT 3: NANOSTRUCTURES	**9**
Zero-, One-, Two- and Three- dimensional structure, Size control of metal Nanoparticles and their properties: Optical, Electronic, Magnetic properties; Surface plasmon Resonance, Change of bandgap; Application: catalysis, electronic devices	
UNIT 4: NANOCOMPOSITES	**9**
Metal-Metal nanocomposites, Polymer-Metal nanocomposites, Ceramic nanocomposites: Dielectric and CMR based nanocomposites. Nano Semiconductors: Nanoscale electronic devices including CMOS, Potentiometric sensors etc., MRAM devices, Spintronic devices including spin valves.	
UNIT 5: APPLICATIONS OF NANO MATERIALS	**9**
Overview of nanomaterials properties and their applications, nano painting, nano coating, nanomaterials for renewable energy, Molecular Electronics and Nanoelectronics – Nanobots- Biological Applications. Emerging technologies for environmental applications- Practice of nanoparticles for environmental remediation and water treatment.	
	TOTAL: 45 PERIODS
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Analysis the basic properties such as structural, physical, chemical properties of nanomaterials and their applications.	

CO2: Acquire knowledge about the different types of nano material synthesis.

CO3: Demonstrate the fundamental understanding of the operation of engine auxiliary systems.

CO4: Develop a deeper knowledge about nano structures.

CO5: Develop a deeper knowledge in the application of nanomaterials in different fields.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	-	-	-	-	-	-	-	-	-	-	-	2	1	-
CO2	1	2	2	2	2	-	-	-	-	-	1	-	2	1	-
CO3	1	2	2	2	2	-	-	-	-	-	1	-	2	1	-
CO4	1	2	2	2	2	-	-	-	-	-	1	-	2	1	-
CO5	1	2	2	2	2	-	-	-	-	-	1	-	2	1	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Mick Wilson, Kamali Kannangara,Geoff Smith, Michelle Simmom, Burkhard Raguse, " Nano Technology: Basic Science & Engineering Technology",Overseas Press, 2005.

2. G. Cao, "Nanostructures & Nanomaterials: Synthesis, Properties &Applications" Imperial College Press, 2004

3. William A Goddard "Handbook of Nanoscience, Engineering and Technology", 3rd Edition, CRC Taylor and Francis group 2012.

REFERENCE BOOKS:

1. R.H.J.Hannink & A.J.Hill, Nanostructure Control, Wood Head Publishing Ltd.,Cambridge, 2006

2. C.N.R.Rao, A.Muller, A.K.Cheetham, The Chemistry of Nanomaterials: Synthesis, Properties and Applications Vol. I & II, 2nd edition, 2005, Wiley VCH Verlag Gibtl & Co

3. Ivor Brodie and Julius J.Muray,'The physics of Micro/Nano – Fabrication',Springer International Edition,2010

4. Carbon Nanotubes: Properties and Applications- Michael J. O'Connell.

WEB RESOURCES:

1. Nano Technology: https://old.amu.ac.in/emp/studym/100016644.pdf

AE606209– AIRCRAFT HIGH TEMPERATURE MATERIALS						
Course Category: Vertical 2	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To learn the concepts of damage mechanism
- To acquire knowledge in of components at elevated temperatures
- To analysis the concept of creep
- To design material for creep resistance
- To educate about high temperature material characterization

UNIT 1: CREEP BEHAVIOUR IN HIGH TEMPERATURE MATERIAL	**9**
Factors influencing functional life of components at elevated temperatures, definition of creep curve, various stages of creep, metallurgical factors influencing various stages, effect of stress, temperatures and strain rate.	
UNIT 2: DESIGN FOR CREEP RESISTANCE	**9**
Design of transient creep time, hardening, strain hardening, expressions of rupture life of creep, ductile and brittle materials, Monkman-Grant relationship.	
UNIT 3: FRACTURE AND SUPER ALLOYS	**9**
Various types of fracture, brittle to ductile from low temperature to high temperature, cleavage fracture due to micro void coalescence – diffusion controlled void growth; fracture maps for different alloys and oxides - Iron base, Nickel base and Cobalt base super alloys, composition control, solid solution strengthening,	
UNIT 4: OXIDATION AND HOT CORROSION	**9**
Oxidation, Pilling, Bedworth ratio, kinetic laws of oxidation – defect structure and control of Oxidation by alloy additions, hot gas corrosion deposit, modified hot gas corrosion, fluxing mechanisms, effect of alloying elements on hot corrosion, interaction of hot corrosion and creep, methods of combat hot corrosion.	
UNIT 5: HIGH TEMPERATURE MATERIALS CHARACTERIZATION	**9**
Classification, production and characteristics – Methods and testing – Determination of mechanical and thermal properties of materials at elevated temperatures – Application of these materials in Thermal protection systems of Aerospace vehicles – super alloys – High temperature material characterization.	
TOTAL: 45 PERIODS	

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Apply the concepts of damage mechanism.

CO2: Describe the knowledge of components at elevated temperatures

CO3: Design materials to able to have creep resistance

CO4: Knowledge about oxidation and corrosion

CO5: Illustrate the high temperature material characterization

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO2	1	3	2	2	2	-	-	-	-	-	1	-	1	-	-
CO3	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-
CO4	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-
CO5	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Raj. R., "Flow and Fracture at Elevated Temperatures",American Society for Metals, USA, 1985.

2. Hertzberg R.W., "Deformation and Fracture Mechanics of Engineering materials", 4th Edition, John Wiley, USA, 1996.

3. Courtney T .H, "Mechanical Behaviour of Materials",McGraw-Hill, USA, 1990.

REFERENCE BOOKS:

1. Boyle J.T, Spencer J, "Stress Analysis for Creep",Butterworths, UK, 1983.

2. Bressers.J., "Creep and Fatigue in High Temperature Alloys", Applied Science, 1981.

3. McLean D., "Directionally Solidified Materials for High Temperature Service",The Metals Society, USA, 1985

WEB RESOURCES:

1. Aircraft High Temperature Material: https://www.youtube.com/watch?v=mwyZ-U6x0h0

Vertical-3

ACIONICS AND DRONE TECHNOLOGY

CURRICULUM

S.No	Course Code	Course Title	Classification		L	T	P	C
1	AE606301	Avionics	PE	Theory	3	0	0	3
2	AE606302	Design of UAV Systems (NPTEL)	PE	Theory	3	0	0	3
3	AE606303	Aerodynamics of Drones	PE	Theory	3	0	0	3
4	AE606304	Control Engineering	PE	Theory	3	0	0	3
5	AE606305	Introduction to PLC(NPTEL)	PE	Theory	3	0	0	3
6	AE606306	Drone Technologies	PE	Theory	3	0	0	3
7	AE606307	Geographical Information Systems (NPTEL)	PE	Theory	3	0	0	3
8	AE606308	Guidance and Control	PE	Theory	3	0	0	3
9	AE606309	Navigation and Communication Systems	PE	Theory	3	0	0	3

AE606301 AVIONICS						
Course Category: Vertical 3	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To introduce the basics of avionics and its needs for civil and military aircrafts.
- To impart knowledge about the avionic architecture and various avionics data buses
- To gain more knowledge on various avionics subsystems
- To analysis the concepts of navigation systems.
- To gain knowledge on auto pilot system

UNIT I INTRODUCTION TO AVIONICS	**9**
Need for avionics in civil and military aircraft and space systems – integrated avionics and weapon systems – Typical avionics subsystems, design, technologies – Introduction to digital computer and memories	
UNIT II DIGITAL AVIONICS ARCHITECTURE	**9**
Avionics system architecture – data buses – MIL-STD-1553B – ARINC – 420 – ARINC – 629.	
UNIT III FLIGHT DECKS AND COCKPITS	**9**
Control and display technologies: CRT, LED, LCD, EL and plasma panel – Touch screen – Direct voice input (DVI) – Civil and Military Cockpits: MFDS, HUD, MFK, HOTAS.	
UNIT IV INTRODUCTION TO NAVIGATION SYSTEMS	**9**
Radio navigation – ADF, DME, VOR, LORAN, DECCA, OMEGA, ILS, MLS – Inertial Navigation Systems (INS) – Inertial sensors, INS block diagram – Satellite navigation systems – GPS	
UNIT V AIR DATA SYSTEMS AND AUTO PILOT	**9**
Air data quantities – Altitude, Air speed, Vertical speed, Mach Number, Total air temperature, Mach warning, Altitude warning – Auto pilot – Basic principles, Longitudinal and lateral auto pilot.	
TOTAL: 45 PERIODS	

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Built Digital avionics architecture.

CO2. Design Navigation system

CO3. Integrate avionics systems using data buses

CO4. Analyze the performance of various cockpit display technologies

CO5. Design autopilot for small aircrafts using MATLAB.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	-	-	1	-	-	-	2	-	-	-	1	1
CO2	3	2	1	-	-	1	-	-	-	2	-	-	-	1	1
CO3	3	2	2	-	-	1	-	-	-	2	-	-	-	2	1
CO4	3	2	2	-	-	1	-	-	-	2	-	-	-	1	1
CO5	3	2	2	-	-	1	-	-	-	2	-	-	-	2	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Spitzer, C.R. "Digital Avionics Systems", The Blackburn Press; 2nd edition 2001
2. Spitzer. C.R. "The Avionics Hand Book", CRC Press, 3rd edition 2017
3. Collinson.R.P.G. "Introduction to Avionics", Springer 3rd edition 2011

REFERENCE BOOKS:

1. Albert Helfrick.D., "Principles of Avionics", Avionics Communications Inc., 2004
2. Middleton, D.H., Ed., "Avionics systems, Longman Scientific and Technical", Longman Group UK Ltd., England, 1989.
3. Pallet.E.H.J., "Aircraft Instruments and Integrated Systems", Pearsons, Indian edition 2011.

WEB RESOURCES:

1.Https://Www.Aviationtoday.Com/

2. https://aea.net/AvionicsNews/

AE606302 DESIGN OF UAV SYSTEMS

Course Category: Vertical 3	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To expose students to concepts needed in modelling and analysing an unmanned system.
- To expose students to the design and development of UAV.
- To expose students to the type of payloads used in UAV.
- To study path planning

- To analysis the avionics hardware used in the UAV

UNIT I INTRODUCTION TO UAV	**9**

History of UAV –classification – Introduction to Unmanned Aircraft Systems--models and prototypes – System Composition-applications

UNIT II THE DESIGN OF UAV SYSTEMS	**9**

Introduction to Design and Selection of the System- Aerodynamics and Airframe Configurations- Characteristics of Aircraft Types- Design Standards and Regulatory Aspects-UK, USA and Europe- Design for Stealth--control surfaces-specifications.

UNIT III AVIONICS HARDWARE	**9**

Autopilot – AGL-pressure sensors-servos-accelerometer –gyros-actuators- power supply-processor, integration, installation, configuration, and testing

UNIT IV COMMUNICATION PAYLOADS AND CONTROLS	**9**

Payloads-Telemetry-tracking-Aerial photography-controls-PID feedback-radio control frequency range – modems-memory system-simulation-ground test-analysis-trouble shooting

UNIT V THE DEVELOPMENT OF UAV SYSTEMS	**9**

Waypoints navigation-ground control software- System Ground Testing- System In-flight Testing- Future Prospects and Challenges-Case Studies – Mini and Micro UAVs.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Design UAV system

CO2. Prepare preliminary design requirements for an unmanned aerial vehicle.

CO3. Identify different hardware for UAV

CO4. Perform system testing for unmanned aerial vehicles.

CO5. Design micro aerial vehicle systems by considering practical limitations

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	-	-	-	-	-	-	1	-	-	-	-	-
CO2	3	2	2	-	-	-	-	-	-	1	-	-	-	1	1
CO3	3	2	2	-	-	-	-	-	-	1	-	-	-	2	2
CO4	3	2	2	-	-	-	-	-	-	1	-	-	-	2	-
CO5	3	2	2	-	2	-	-	-	-	1	-	-	-	1	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.Paul G Fahlstrom, Thomas J Gleason, "Introduction to UAV Systems", UAV Systems, Wiley; 4th edition 2012
2.Reg Austin "Unmanned Aircraft Systems UAV design, development and deployment", 1st edition 2011
REFERENCE BOOKS:
1.Dr. Armand J. Chaput, "Design of Unmanned Air Vehicle Systems", Lockheed Martin Aeronautics Company, 2001
2.Kimon P. Valavanis, "Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy", Springer, 1st edition 2010
3.Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, 2nd edition 2017
WEB RESOURCES: 1. Https://Erau.Libguides.Com/Uas/Websites **2.** Https://Www.Sciencedirect.Com/Topics/Engineering/Unmanned-Aerial-Vehicle

AE606303 AERODYNAMICS OF DRONES						
Course Category: Vertical 3	**Course Type:** **Theory**	**L** **3**	**T** **0**	**P** **0**	**C** **3**	
COURSE OBJECTIVES:						
• To introduce students to the basic concepts of payloads in UAV. • To understand the various sensor system of an UAV • To introduce with the concepts of data algorithms and architectures. • To introduce the concepts of artificial neural networks. • To expose students to the concept of fuzzy logic						
UNIT I PAYLOAD FOR UAV						**9**
Introduction – Types – Non-dispensable Payloads - Electro-optic Payload Systems - Electro-optic Systems Integration - Radar Imaging Payloads - Other Non-dispensable Payloads - Dispensable Payloads - Payload Development.						
UNIT II SENSORS						**9**
Data fusion applications to multiple sensor systems - Selection of sensors - Benefits of multiple sensor systems - Influence of wavelength on atmospheric attenuation - Fog characterization - Effects of operating frequency on MMW sensor performance - Absorption of MMW energy in rain						

and fog - Backscatter of MMW energy from rain - Effects of operating wavelength on IR sensor performance - Visibility metrics - Atmospheric and sensor system computer simulation models

UNIT III DATA FUSION ALGORITHMS AND ARCHITECTURES **9**

Definition of data fusion - Level 1 processing - Detection, classification, and identification algorithms for data fusion - State estimation and tracking algorithms for data fusion - Level 2, 3, and 4 processing - Data fusion processor functions - Definition of an architecture - Data fusion architectures - Sensor-level fusion - Central-level fusion - Hybrid fusion

UNIT IV ARTIFICIAL NEURAL NETWORKS **9**

Applications of artificial neural networks - Adaptive linear combiner - Linear classifiers - Capacity of linear classifiers - Nonlinear classifiers - Madaline – Feed forward network - Capacity of nonlinear classifiers - Supervised and unsupervised learning - Supervised learning rules - Voting Logic Fusion

UNIT V FUZZY LOGIC AND FUZZY NEURAL NETWORKS **9**

Conditions under which fuzzy logic provides an appropriate solution - Illustration of fuzzy logic in an automobile antilock braking system - Basic elements of a fuzzy system - Fuzzy logic processing - Fuzzy centroid calculation

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the students will be able to

CO1. Calculate the payloads in UAV.

CO2. Explain the concepts sensor systems

CO3. Predict the data fusion algorithms and architectures.

CO4. Learn the basics neural network systems

CO5. Design various network schemes

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	2	-	-	-	-	-	-	2	-	-	-	2	2
CO2	3	2	2	-	-	-	-	-	-	2	-	-	-	2	2
CO3	3	2	2	-	-	-	-	-	-	2	-	-	-	2	2
CO4	2	2	2	2	2	-	-	-	-	2	-	-	-	2	2
CO5	2	2	2	2	2	-	-	-	-	2	-	-	-	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Reg Austin "Unmanned Aircraft Systems UAV design, development and deployment", 1st edition 2011

2.David L. Hall, Sonya A. H. McMullen "Mathematical Techniques in Multi-sensor Data Fusion", by Artech, 2004

3.Martin Liggins II David Hall, James "Handbook of Multisensor Data Fusion: Theory and Practice", Second Edition (Electrical Engineering & Applied Signal Processing Series), 2008.

REFERENCE BOOKS:

1.Lawrence A. Klein, "Sensor and Data Fusion: A Tool for Information Assessment and Decision Making", Second Edition, SPIE Press, 2013

2.Jitendra R. Raol, "Multi-Sensor Data Fusion with MATLAB", CRC Press, 2010

WEB RESOURCES:

1.Https://Www.Youtube.Com/Watch?V=Ejfcnqs6hd4

2. https://www.wired.com/2017/05/the-physics-of-drones/

AE606304 CONTROL ENGINEERING						
Course Category: Vertical 3	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To introduce the mathematical modeling of systems, open loop and closed loop systems and analyses in time domain and frequency domain.
- To impart the knowledge on the concept of stability and various methods to analyze stability in both time and frequency domain.
- To introduce sampled data control system.
- To explain the concept of stability
- To analysis about digital controllers

UNIT I INTRODUCTION	**9**
Historical review, Simple pneumatic, hydraulic and thermal systems, Series and parallel system, Analogies, mechanical and electrical components, Development of flight control systems	
UNIT II OPEN AND CLOSED LOOP SYSTEMS	**9**
Feedback control systems – Control system components - Block diagram representation of control systems, Reduction of block diagrams, Signal flow graphs, Output to input ratios.	
UNIT III CHARACTERISTIC EQUATION AND FUNCTIONS	**9**
Laplace transformation, Response of systems to different inputs viz., Step impulse, pulse, parabolic and	

sinusoidal inputs, Time response of first and second order systems, steady state errors and error constants of unity feedback circuit.

UNIT IV CONCEPT OF STABILITY	**9**

Necessary and sufficient conditions, Routh-Hurwitz criteria of stability, Root locus and Bode techniques, Concept and construction, frequency response.

UNIT V SAMPLED DATA SYSTEMS	**9**

Z-Transforms Introduction to digital control system, Digital Controllers and Digital PID controllers

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Apply mathematical knowledge to model the systems and analyse the frequency domain.

CO2.Check the stability of the both time and frequency domain.

CO3.Solve simple pneumatic, hydraulic and thermal systems, Mechanical and electrical component analogies-based problems.

CO4. Solve the Block diagram representation of control systems, Reduction of block diagrams, Signal flow graph and problems based on it.

CO5. Explain the digital control system, Digital Controllers and Digital PID Controllers

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	2	2	-	-	-	-	-	2	-	-	2	2	2
CO2	2	2	2	2	-	-	-	-	-	2	-	-	2	2	2
CO3	2	2	2	2	-	-	-	-	-	2	-	-	2	2	2
CO4	2	2	2	2	-	-	-	-	-	2	-	-	2	2	2
CO5	2	2	2	2	-	-	-	-	-	2	-	-	2	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.Control systems Nagoorkani RBA Publications 3rd edition 2017

2.OGATO, Modern Control Engineering, Pearson Education India; 5th edition (1 January 2015)

REFERENCE BOOKS:

1.Houpis, C.H. and Lamont, G.B. "Digital control Systems", McGraw Hill Book co., New York, U.S.A. 1995.

2.Kuo, B.C. "Automatic control systems", Prentice-Hall of India Pvt. Ltd., New Delhi, 1998

3.Naresh K Sinha, "Control Systems", New Age International Publishers, New Delhi, 1998

WEB RESOURCES:
1. Http://Www.Learncontrolsystems.Com/
2. Https://Www.Ieeecss.Org/

AE606305 INTRODUCTION TO PLC						
Course Category: Vertical 3	**Course Type:** **NPTEL**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- Basic PLC terminologies digital principles, PLC architecture and operation.
- Familiarize different programming language of PLC.
- Develop PLC logic for simple applications using ladder logic.
- Analysis the hardware and software behind PLC and SCADA.
- Exposures about communication architecture of PLC/SCADA

UNIT I INTRODUCTION TO PLC	**9**
Introduction to PLC: Microprocessor, I/O Ports, Isolation, Filters, Drivers, Microcontrollers/DSP, PLC/DDC- PLC Construction: What is a PLC, PLC Memories, PLC I/O, , PLC Special I/O, PLC Types.	
UNIT II PLC INSTRUCTIONS	**9**
PLC Basic Instructions: PLC Ladder Language- Function block Programming- Ladder/Function Block functions- PLC Basic Instructions, Basic Examples (Start Stop Rung, Entry/Reset Rung) - Configuration of Sensors, Switches, Solid State Relays-Interlock examples- Timers, Counters, Examples.	
UNIT III PLC PROGRAMMING	**9**
Different types of PLC program, Basic Ladder logic, logic functions, PLC module addressing, registers basics, basic relay instructions, Latching Relays, arithmetic functions, comparison functions, data handling, data move functions, timer-counter instructions, input-output instructions, sequencer instructions	
UNIT IV COMMUNICATION OF PLC AND SCADA	**9**
Communication Protocol – Modbus, HART, Profibus- Communication facilities SCADA: - Hardware and software, Remote terminal units, Master Station and Communication architectures	
UNIT V CASE STUDIES	**9**
Stepper Motor Control- Elevator Control-CNC Machine Control- conveyor control-Interlocking Problems	
	TOTAL: 45 PERIODS
COURSE OUTCOMES: At the end of the course, the student will be able to	

CO1. Know the basic requirement of a PLC input/output devices and architecture

CO2 Ability to apply Basics Instruction Sets used for ladder Logic and Function Block Programming.

CO3. Ability to design PLC Programmes by Applying Timer/Counter and Arithmetic and Logic Instructions Studied for Ladder Logic and Function Block.

CO4. Able to develop a PLC logic for a specific application on real world problem

CO5. Ability to Understand the Concepts of Communication used for PLC/SCADA

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	-	-	-	-	-	-	2	-	-	2	2	2
CO2	3	2	2	-	-	-	-	-	-	2	-	-	2	-	-
CO3	3	2	2	-	2	-	-	-	-	2	-	-	2	2	2
CO4	3	2	2	-	-	-	-	-	-	2	-	-	2	-	-
CO5	3	2	2	-	-	-	-	-	-	2	-	-	2	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.Frank Petruzzula, Programmable Logic Controllers, Tata Mc-Graw Hill 5th Edition 2019

2. John W. Webb, Ronald A. Reis, Programmable Logic Controllers Principles and Applications, PHI publication 5th edition 2002

REFERENCE BOOKS:

1. Madhuchannd Mitra and Samerjit Sengupta, Programmable Logic Controllers Industrial Automation an Introduction, Penram International Publishing Pvt. Ltd. 2nd edition 2017

2. J. R. Hackworth and F. D. Hackworth, Programmable Logic Controllers Principles and Applications, Pearson publication 3rd edition 2019

WEB RESOURCES:

Https://Instrumentationtools.Com/Resources-Tab-In-Siemens-Plc/

AE606306 DRONE TECHNOLOGIES						
Course Category: Vertical 3	**Course Type: THEORY**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To analysis the basics of drone concepts
- To learn and understand the fundaments of design, fabrication and programming of drone
- To impart the knowledge of an flying and operation of drone
- To know about the various applications of drone
- To analysis the safety risks and guidelines of fly safely

UNIT – I INTRODUCTION TO DRONE TECHNOLOGY	**9**
Drone Concept - Vocabulary Terminology- History of drone - Types of current generation of drones based on their method of propulsion- Drone technology impact on the businesses- Drone business through entrepreneurship- Opportunities/applications for entrepreneurship and employability	
UNIT – II DRONE DESIGN, FABRICATION AND PROGRAMMING	**9**
Classifications of the UAV -Overview of the main drone parts- Technical characteristics of the parts - Function of the component parts -Assembling a drone- The energy sources- Level of autonomy- Drones configurations -The methods of programming drone- Download program - Install program on computer- Running Programs- Multi rotor stabilization- Flight modes -Wi-Fi connection.	
UNIT – III DRONE FLYING AND OPERATION	**9**
Concept of operation for drone -Flight modes- Operate a small drone in a controlled environment- Drone controls Flight operations –management tool –Sensors - Onboard storage capacity - Removable storage devices- Linked mobile devices and applications	
UNIT – IV DRONE COMMERCIAL APPLICATIONS	**9**
Choosing a drone based on the application -Drones in the insurance sector- Drones in delivering mail, parcels and other cargo- Drones in agriculture- Drones in inspection of transmission lines and power distribution - Drones in filming and panoramic picturing	
UNIT – V FUTURE DRONES AND SAFETY	**9**
The safety risks- Guidelines to fly safely -Specific aviation regulation and standardization- Drone license- Miniaturization of drones- Increasing autonomy of drones -The use of drones in swarms	
	TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Know about a various type of drone technology, drone fabrication and programming

CO2 Execute the suitable operating procedures for functioning a drone

CO3. Select appropriate sensors and actuators for Drones

CO4. Develop a drone mechanism for specific applications

CO5. Create the programs for various drones

CO'S PO'S&PSO'S MAPPING

1- low, 2 - medium, 3 - high, '-' no correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	-	-	-	-	-	-	1	-	-	-	-	-
CO2	3	2	2	-	-	-	-	-	-	1	-	-	-	1	1
CO3	3	2	2	-	-	-	-	-	-	1	-	-	-	2	2
CO4	3	2	2	-	-	-	-	-	-	1	-	-	-	2	-
CO5	3	2	2	-	2	-	-	-	-	1	-	-	-	1	1

TEXT BOOKS:

1. Daniel Tal and John Altschuld, "Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation", 2021 John Wiley & Sons, Inc

2. Terry Kilby and Belinda Kilby, "Make:Getting Started with Drones ",Maker Media, Inc, 2016

REFERENCE BOOKS:

1. John Baichtal, "Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs", Que Publishing, 2016

2. Zavrsnik, "Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance", Springer, 2018.

WEB RESOURCES:

1.https://iitram.ac.in

AE606307 GEOGRAPHICAL INFORMATION SYSTEMS						
Course Category: Vertical 3	**Course Type: NPTEL**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To impart the knowledge on basic components, data preparation and implementation of Geographical Information System.
- To learn and understand the fundaments of spatial data models
- To impart the knowledge on data input and topology
- To know about the various GIS standards.
- To analysis the data management and its output

UNIT I FUNDAMENTALS OF GIS	**9**
Introduction to GIS - Basic spatial concepts - Coordinate Systems - GIS and Information Systems – Definitions – History of GIS - Components of a GIS – Hardware, Software, Data, People, Methods – Proprietary and open source Software - Types of data – Spatial, Attribute data- types of attributes – scales/ levels of measurements	
UNIT II SPATIAL DATA MODELS	**9**
Database Structures – Relational, Object Oriented – Entities – ER diagram - data models - conceptual, logical and physical models - spatial data models – Raster Data Structures – Raster Data Compression - Vector Data Structures - Raster vs Vector Models- TIN and GRID data models	
UNIT III DATA INPUT AND TOPOLOGY	**9**
Scanner - Raster Data Input – Raster Data File Formats – Geo referencing – Vector Data Input – Digitizer – Datum Projection and reprojection -Coordinate Transformation – Topology - Adjacency, connectivity and containment – Topological Consistency – Non topological file formats - Attribute Data linking – Linking External Databases – GPS Data Integration	
UNIT IV DATA QUALITY AND STANDARDS	**9**
Data quality - Basic aspects - completeness, logical consistency, positional accuracy, temporal accuracy, thematic accuracy and lineage – Metadata – GIS Standards –Interoperability - OGC - Spatial Data Infrastructure	
UNIT V DATA MANAGEMENT AND OUTPUT	**9**
Import/Export – Data Management functions- Raster to Vector and Vector to Raster Conversion - Data Output - Map Compilation – Chart/Graphs – Multimedia – Enterprise Vs. Desktop GIS-distributed GIS.	
	TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Basic idea about the fundamentals of GIS.

CO2 Understand the types of data models.

CO3. Get knowledge about data input and topology

CO4. Gain knowledge on data quality and standards

CO5. Analysis data management functions and data output

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	2	-	-	-	-	-	-	2	-	-	-	-	-
CO2	2	2	2	-	-	-	-	-	-	2	-	-	2	-	2
CO3	2	2	2	-	-	-	-	-	-	2	-	-	-	2	-
CO4	2	2	2	-	-	-	-	-	-	2	-	-	2	-	2
CO5	2	2	2	-	-	-	-	-	-	2	-	-	-	-	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Kang - Tsung Chang, Introduction to Geographic Information Systems, McGraw Hill Publishing, 2nd Edition, 2011.

2. Ian Heywood, Sarah Cornelius, Steve Carver, Srinivasa Raju, "An Introduction Geographical Information Systems, Pearson Education, 2nd Edition,2007

REFERENCE BOOKS:

1. Lo. C. P., Albert K.W. Yeung, Concepts and Techniques of Geographic Information Systems, Prentice-Hall India Publishers, 2006

WEB RESOURCES:

1.Https://Education.Nationalgeographic.Org/Resource/Geographic-Information-System-Gis/

AE606308 GUIDANCE AND CONTROL						
Course Category: Vertical 3	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To learn about the aircraft equations of motion and method of linearization.
- To learn about the operating principle of guidance law.
- To study about the augmentation systems
- To study longitudinal stability and to design the longitudinal autopilot.
- To study lateral stability and to design the lateral autopilot

UNIT I INTRODUCTION	**9**
Introduction to Guidance and control - Definition, Historical background – Coordinate Frame - Equations of motion – Linearization.	
UNIT II AUGMENTATION SYSTEMS	**9**
Need for automatic flight control systems, Stability augmentation systems, control augmentation systems, Design of Limited authority and Full Authority Augmentation systems - Gain scheduling concepts.	
UNIT III LONGITUDINAL AUTOPILOT	**9**
Displacement Autopilot -Pitch Orientation Control system, Acceleration Control System, Glide Slope Coupler and Automatic Flare Control and Flight path stabilization, Longitudinal control law design using back stepping algorithm.	
UNIT IV LATERAL AUTOPILOT	**9**
Damping of the Dutch Roll, Methods of Obtaining Coordination, Yaw Orientation Control system, turn compensation, Automatic lateral Beam Guidance. Introduction to Fly-by-wire flight control systems, Lateral control law design using back stepping algorithm.	
UNIT V MISSILE AND LAUNCH VEHICLE GUIDANCE	**9**
Operating principles and design of guidance laws, homing guidance laws- short range, Medium range and BVR missiles, Launch Vehicle- Introduction, Mission requirements, Implicit guidance schemes, Explicit guidance, Q guidance scheme	
TOTAL: 45 PERIODS	

COURSE OUTCOMES: At the end of the course, the students will be able to

CO1.Explain the equations governing the aircraft dynamics and the process of linearizing them.

CO2.Define the various guidance schemes and requirements for aircrafts and missiles.

CO3. Apply the principle of stability and control augmentation systems.

CO4. Analyse the oscillatory modes and methods of suppressing them

CO5. Design the controller for lateral, longitudinal and directional control of aircrafts.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	2	-	-	-	-	-	-	2	-	-	2	2	-
CO2	3	2	2	-	-	-	-	-	-	2	-	-	2	2	2
CO3	3	2	2	-	-	-	-	-	-	2	-	-	2	2	-
CO4	3	2	2	-	-	-	-	-	-	2	-	-	-	2	2
CO5	3	2	2	-	-	-	-	-	-	2	-	-	2	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.Blakelock, J. H., "Automatic Control of Aircraft and Missiles", Wiley India Pvt Ltd; Second edition (24 February 2011)

2.Collinson R.P.G, 'Introduction to Avionics', Springer 2012

3.Garnel. P. & East. D. J, 'Guided Weapon control systems', Pergamon Press, Oxford, 1977

REFERENCE BOOKS:

1.Michael V. Cook 'Flight Dynamics Principles: A Linear Systems Approach to Aircraft Stability and Control', Elsevier, 2010.

2.Nelson R.C, 'Flight stability & Automatic Control', McGraw Hill, 2nd edition 2017

3.Pierre T. Kabamba, Anouck R. Girard. 'Fundamentals of Aerospace Navigation and Guidance', Cambridge university press, 2014

WEB RESOURCES:

1.Https://Www.Sciencedirect.Com/Science/Article/Abs/Pii/B9781483167169500060

AE606309 NAVIGATION AND COMMUNICATION SYSTEMS						
Course Category: Vertical 3	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To introduce various types of navigation systems.
- To understand the dead reckoning navigation system and its error correction.
- To know satellite navigation and hybrid navigation system integration
- To learn the concepts of radio transmitters and receivers
- To acquire knowledge about weather radar systems and DME

UNIT I INERTIAL NAVIGATION SYSTEMS	**9**

Introduction to navigation – Types -INS components- transfer function and errors - Earth in inertial space - Coriolis Effect – INS Mechanization. Platform and Strap down – Navigation algorithms - INS system block diagram, Different co-ordinate systems – Transformation Techniques - Schuler Tuning – compensation errors - Gimbal lock - Initial calibration and Alignment Algorithms

UNIT II RADIO NAVIATION & SATELLITE NAVIGATION	**9**

Different types of radio navigation- ADF, VOR, DME - Doppler – Hyperbolic Navigations -LORAN, DECCA and Omega – TACAN. Introduction to GPS -system description -basic principles –position and velocity determination signal Structure -DGPS, Introduction to Kalman filtering-Estimation and mixed mode navigation Integration of GPS and INS-utilization of navigation systems in aircraft.

UNIT III RADIO TRANSMITTERS AND RECEIVERS	**9**

Functions of a Radio transmitter, Microphones, types, Block diagram explanation of a Radio transmitter, Modulation and its types and Antenna, Antenna couplers, Qualities of a good Radio receiver, Block diagram of a simple radio receiver and super heterodyne receiver

UNIT IV AIRCRAFT COMMUNICATION SYSTEMS	**9**

Basics of aircraft communication system, types Very High Frequency Communication system, Description, Principle, Operation of VHF Communication system and its layout on aircraft, High Frequency communication system, Description, Principle and operation of High Frequency communication system and its layout on aircraft. Satellite communication system, Description, Operation and its layout on aircraft

UNIT V WEATHER RADAR SYSTEM AND DME	**9**

Operating principles and design of guidance laws, homing guidance laws- short range, Medium range and BVR missiles, Launch Vehicle- Introduction, Mission requirements, Implicit guidance schemes, Explicit guidance, Q guidance scheme

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the students will be able to

CO1. Analysis the advanced concepts of Aircraft Navigation

CO2.To provide the necessary mathematical knowledge those are needed in modeling the navigation process and methods.

CO3. The students will have an exposure on various Navigation systems such as Inertial Measurement systems, Radio Navigation Systems, Satellite Navigation – GPS.

CO4. Landing aids and will be able to deploy these skills effectively in the analysis and understanding of navigation systems in an aircraft.

CO5. Learn and apply the principles of Radar and its related components.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	3	-	-	-	-	-	-	2	-	-	3	-	-
CO2	3	2	2	-	-	-	-	-	-	2	-	-	-	2	2
CO3	2	2	2	-	-	-	-	-	-	2	-	-	2	2	2
CO4	2	2	2	-	-	-	-	-	-	2	-	-	2	2	2
CO5	2	2	2	-	-	-	-	-	-	2	-	-	-	-	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Avionics Navigation Systems –Myron Kayton, Walter R.Fried, Second Edition,Wiley India Edition,2010

2. Aircraft Communications and Navigation systems – Mike Tooley and David Wyatt, Reed Elsevier, India, Noida, Edition – 2007)

REFERENCE BOOKS:

1.Aircraft Electricity and electronics by Thomas K Eismin (Fifth edition-1994, McGraw- Hill Book Co)

2.Aircraft Radio system by James Powell, Sterling book house, Mumbai, Indian edition - 2006

WEB RESOURCES:

1.Https://Www.Aeroclass.Org/Aircraft-Navigation/

2. https://www.aircraftnerds.com/2018/08/how-does-aircraft-navigation-system-work.html

Vertical-4

ROCKETS AND MISSILES

CURRICULUM

S. No.	Course Code	Course Title	Classification		L	T	P	C
1	AE606401	Basics of Rockets and missiles	PE	Theory	3	0	0	3
2	AE606402	Missile Aerodynamics	PE	Theory	3	0	0	3
3	AE606403	Space Mechanics	PE	Theory	3	0	0	3
4	AE606404	Cryogenics (NPTEL)	PE	Theory	3	0	0	3
5	AE606405	Remote Sensing Concepts	PE	Theory	3	0	0	3
6	AE606406	Missile Guidance and Control (NPTEL)	PE	Theory	3	0	0	3
7	AE606407	Chemical Rockets	PE	Theory	3	0	0	3
8	AE606408	Launch Vehicle Technology	PE	Theory	3	0	0	3
9	AE606409	Combustion Theory	PE	Theory	3	0	0	3
10	AE 606410	Rocket Propulsion	PE	Theory	3	0	0	3

AE606401 BASICS OF ROCKETS AND MISSILES						
Course Category: Vertical 4	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

- To impart knowledge on the aerodynamic characteristics of different classes of missiles
- To provide the methodology to estimate the drag on a subsonic/supersonic missile.
- To introduce the 1D and 2D motion of rockets in free space and in homogeneous gravitational field.
- To explore the need for multi staging in rockets
- To make the student understand the concept of vorticity, irrotationality, theory of airfoils and wing sections

UNIT 1: INTRODUCTION	**9**

Space launch Vehicles and military missiles, function, types, role, mission, mission profile, thrust profile, propulsion system, payload, staging, control and guidance requirements, performance measures, design, construction, operation, similarities and differences. Some famous space launch vehicles and strategic missiles.

UNIT 2: SOLID PROPELLANT ROCKET MOTOR SYSTEMS	**9**

Solid Propellant rocket motors, principal features, applications. Solid propellants, types, composition, properties, performance. Propellant grain, desirable properties, grain configuration, preparation, loading, structural design of grain. Liners, insulators and inhibitors, function, requirements, materials. Rocket motor casing – materials. Nozzles, types, design, construction, thermal protection. Igniters, types, construction.

UNIT 3: AERODYNAMICS OF ROCKETS AND MISSILES	**9**

Classification of missiles. Airframe components of rockets and missiles, Forces acting on a missile while passing through atmosphere, method of describing aerodynamic forces and moments, lateral aerodynamic moment, lateral damping moment, longitudinal moment of a rocket, lift and drag forces, drag estimation, body upwash and downwash in missiles. Rocket dispersion, re-entry body design considerations.

UNIT 4: LAUNCH VEHICLE DYNAMICS	**9**

Tsiolkovsky's rocket equation, range in the absence of gravity, vertical motion in the earth's gravitational field, inclined motion, flight path at constant pitch angle, motion in the atmosphere, the gravity turn – the culmination altitude, multi staging. Earth launch trajectories – vertical segment, the gravity turn, constant pitch trajectory, orbital injection. Actual launch vehicle trajectories.

UNIT 5: ROCKET TESTING	**9**

Ground Testing and Flight Testing, Types of Tests facilities and safeguards, monitoring and control of toxic materials, instrumentation and data management. Ground Testing, Flight Testing, Trajectory

monitoring, post -accident procedures. Description of a typical space launch vehicle launch procedure. Materials: Criteria for selection of materials for rockets and missiles, requirements for choice of materials for propellant tanks, liners, insulators, inhibitors, at cryogenic temperatures, requirements of materials at extremely high temperatures, requirements of materials for thermal protection and for pressure vessels.

TOTAL: 45 PERIODS

COURSE OUTCOMES: On successful completion of this course, the student will be able to

CO1: Identify the types of space launch vehicles and missiles.

CO2: Distinguish the solid and liquid propellant motors.

CO3: Classify different types of materials used for rockets and missies.

CO4: Optimize a multi stage rocket based on given constraint

CO5: An ability to apply airfoil theory to rocket testing

CO6: Ability to understand the subsonic wing theory.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2		3	-	-	2	2	-	-	-	2	3	2	-	3
CO2	2	3	2	-	3	-	-	-	-	-	2	2	2	3	2
CO3	2	3	2	-	3	-	-	-	-	-	2	2	2	3	2
CO4	-	2	2	2	2	2	2	-	2	-	2	-	-	2	2
CO5	2	3	2	2	3	-	-	-	-	-	-	3	2	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Rocket Propulsion Element-George P Sutton and Oscar Biblarz Missile Aerodynamics-Jack N Neilson
2. Sutton,G.P. "Rocket Propulsion Elements", John Wiley & Sons; 8thEdition 2010.
3. Anderson, J.D., "Fundamentals of Aerodynamics", McGraw Hill Book Co. Fifth edition2011
4. E.RathaKrishnan "Theoretical Aerodynamics" Wiley First edition 2013
5. Houghton, E.L., and Caruthers, N.B., "Aerodynamics for Engineering students", Edward Arnold Publishers Ltd., London, 1989

REFERENCE BOOKS:

1. Rocket Propulsion and Space-Flight Dynamics-Cornelisse, J.W, Schoyer H.F.R. and Wakker, K.F
2. Rocket and Spacecraft propulsion-Turner, M.J.L
3. Space Vehicle Dynamics-Ball, K.J., Osborne, G.F

AE606402 MISSILE AERODYNAMICS

Course Category: Vertical 8	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To impart knowledge on the aerodynamic characteristics of different classes of missiles
- To provide the methodology to estimate the drag on a subsonic/supersonic missile.
- To introduce the 1D and 2D motion of rockets in free space and in homogeneous gravitational field.
- To explore the need for multi staging in rockets
- To make the student understand the concept of vorticity, irrotationality, theory of airfoils and wing

sections

UNIT 1: CLASSIFICATION OF ROCKETS AND LAUNCH VEHICLES	9

Airframe components of rockets and Launch Vehicles –forces acting on a missile while passing through atmosphere –slender body aerodynamics –method of describing forces and moments –lift force and lateral moment –lateral aerodynamic damping moment –longitudinal moment –drag estimation-Rocket Dispersion.

UNIT 2: AERODYNAMICS OF ROCKETS AND LAUNCH VEHICLES	9

Airframe components of rockets and Launch Vehicles –forces acting on a missile while passing through atmosphere –slender body aerodynamics –method of describing forces and moments –lift force and lateral moment –lateral aerodynamic damping moment –longitudinal moment –drag estimation-Rocket Dispersion

UNIT 3: ROCKET MOTION IN FREE SPACE AND GRAVITATIONAL FIELD	9

One dimensional and two-dimensional rocket motions in free space and homogeneous gravitational fields –description of vertical, inclined and gravity turn trajectories –determination of range and altitude –simple approximations to burnout velocity and altitude –estimation of culmination time and altitude –Ballistic trajectories.

UNIT 4: CONTROL OF ROCKETS AND LAUNCH VEHICLES	9

Introduction to aerodynamic control and jet control methods-thrust control methods –various types of jet control methods including secondary injection thrust vector control for launch vehicles –Characteristics of aerodynamic control methods

UNIT 5: AIRFOIL & SUBSONIC WING THEORY	9

Cauchy-Riemann relations, complex potential, methodology of conformal transformation, Kutta Joukowski transformation and its applications, Karmann-Trefftz profiles, thin airfoil theory and its applications. Vortex filament, biot and savart law, bound vortex and trailing vortex, horse shoe vortex, Prandtl's lifting line theory and its limitations

TOTAL: 45 PERIODS

COURSE OUTCOMES: On successful completion of this course, the student will be able to

CO1: Classify missiles based on different aspects .

CO2: Calculate the forces and moments that act on a missile in atmosphere..

CO3: Perform the calculations pertaining to altitude and range covered by rockets in homogeneous gravitational field.

CO4: Optimize a multi stage rocket based on given constraint

CO5: An ability to apply airfoil theory to predict airfoil performance

CO6: Ability to understand the subsonic wing theory.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2		3	-	-	2	2	-	-	-	2	3	2	-	3
CO2	2	3	2	-	3	-	-	-	-	-	2	2	2	3	2
CO3	2	3	2	-	3	-	-	-	-	-	2	2	2	3	2
CO4	-	2	2	2	2	2	2	-	2	-	2	-	-	2	2
CO5	2	3	2	2	3	-	-	-	-	-	-	3	2	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Cornelisse, J.W., "Rocket Propulsion and Space Dynamics", J.W. Freeman &Co.,Ltd, London, 1982.
2. Sutton,G.P. "Rocket Propulsion Elements", John Wiley & Sons; 8thEdition 2010.
3. Anderson, J.D., "Fundamentals of Aerodynamics", McGraw Hill Book Co. Fifth edition2011
4. E.RathaKrishnan "Theoretical Aerodynamics" Wiley First edition 2013
5. Houghton, E.L., and Caruthers, N.B., "Aerodynamics for Engineering students", Edward Arnold Publishers Ltd., London, 1989

REFERENCE BOOKS:

1. Mathur, M.L.and Sharma, R.P., "Gas Turbine, Jet and Rocket Propulsion", Standard Publishers & Distributors, Delhi, 2nd edition 2014.
2. Clancy, L J.," Aerodynamics", Pitman,Company Second edition 1986
3. Milne, L.H., Thomson, Theoretical Aerodynamics, Dover Publishing company Second edition 1985.

AE606403 SPACE MECHANICS

Course Category: Vertical 4	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To introduce special needs for manned space missions and pre calculation of space environment to students.
- To impart the knowledge on basis concepts of space mechanics like Newton's law of gravitation and its applications, reference co-ordinate systems and position vs time relationships of celestial bodies.
- To acquaint students on the methodologies for computation of satellite orbit perturbations
- To elucidate the concepts of space of influence and its purpose in computing interplanetary trajectories to students.
- To impart knowledge of various phases of ballistic trajectories and special features of re-entry phase to students.

UNIT 1: SPACE ENVIRONMENT **9**

Peculiarities of space environment and its description– effect of space environment on materials of spacecraft structure and astronauts- manned space missions – effect on satellite life time.

UNIT 2: BASIC CONCEPTS AND THE GENERAL N- BODY PROBLEM **9**

The solar system – reference frames and coordinate systems – terminology related to the celestial sphere and its associated concepts – Kepler's laws of planetary motion and proof of the laws – Newton's universal law of

gravitation - the many body problem - Lagrange-Jacobi identity – the circular restricted three body problem – libration points – the general N-body problem – two body problem – relations between position and time.

UNIT 3: SATELLITE INJECTION AND SATELLITE PERTURBATIONS **9**

General aspects of satellite injection – satellite orbit transfer – various cases – orbit deviations due to injection errors – special and general perturbations – Cowell's method and Encke's method – method of variations of orbital elements – general perturbations approach..

UNIT 4: INTERPLANETARY TRAJECTORIES **9**

Two Dimensional Interplanetary Trajectories –Fast Interplanetary Trajectories – Three Dimensional Interplanetary Trajectories – Launch of Interplanetary Spacecraft –Trajectory about the Target Planet – concept of sphere of influence – Lambert's theorem.

UNIT 5: BALLISTIC MISSILE TRAJECTORIES **9**

Introduction to ballistic missile trajectories – boost phase – the ballistic phase – trajectory geometry – optimal flights – time of flight – re-entry phase – the position of impact point – influence coefficients.s

TOTAL: 45 PERIODS

COURSE OUTCOMES: On successful completion of this course, the student will be able to

CO1: Acquire knowledge on the unique features of space environment and its effect on space craft and astronauts.

CO2: Compute position of bodies in orbits in terms of their coordinates with respect to time.

CO3: Gain insights on the intricate aspects of satellite injectors.

CO4: Determine and compute interplanetary trajectories

CO5: Make calculations of all important phases of missile trajectories

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	2	-	-	2	2	-	2	-	2	2	2	2	2
CO2	2	2	-	2	2	-	2	-	2	-	2	2	2	2	-
CO3	2	2	2	2	2	2	-	-	2	-	2	2	2	2	2
CO4	2	2	2	-	2	-	-	-	2	-	2	2	2	2	2
CO5	2	2	-	2	2	-	-	-	2	-	2	2	2	2	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

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

2. Parker, E.R., "Materials for Missiles and Spacecraft", Mc.Graw Hill Book Co. Inc., 1982.

REFERENCE BOOKS:

1. Sutton, G.P., "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 5Th Edition,1993

WEB RESOURCES:

1. space mechanics: https://nptel.ac.in/courses/1034569140

AE606404 CRYOGENICS						
Course Category: Vertical 4	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- Identify cryogenic substance and examine its characteristics in cryogenic environments.
- Gain knowledge in various measurement systems.
- Explain the importance of cryogenic insulations.
- Explain the hazard waste management and superconductive devices.
- Obtain ideas in the various applications of cryogenic systems.

UNIT 1: INTRODUCTION	**9**

Meaning & definition of cryogenics, Importance of cryogenics studies, properties of engineering materials at cryogenic temperatures, Thermo physical and fluid dynamic properties of liquid and gas hydrogen and oxygen, Liquefaction systems of hydrogen and oxygen gases, Joule Thomson effect and inversion curve; Adiabatic and isenthalpic expansion with their comparison.

UNIT 2: CRYOGENIC MEASUREMENT SYSTEMS	**9**

Temperature measurements, pressure measurements, flow measurements, liquid level measurements, fluid quality measurements.

UNIT 3: IMPORTANCE OF CRYOGENIC INSULATIONS	**9**

Various factors for selection of insulations, various types such as expanded foams, gas filled & fibrous insulation, vacuum insulation, evacuated powder& fibrous insulation, opacities powder insulation, multi layer insulation, comparison of performance of various insulations.

UNIT 4: HAZARD WASTE MANAGEMENT	**9**

Physical hazards, Chemical hazards, Physiological hazards, Combustion hazards, oxygen hazards,, accidents in cryogenic plants & Prevention Safety in handling of cryogens, care for storage of gaseous cylinders, familiarization with regulations of environmental safety department. Powder insulation by boil off calorimeter method.

UNIT 5: SALIENT APPLICATIONS OF CRYOGENIC SYSTEMS	**9**

Super conductive devices such as bearings, motors, cryotrons, magnets, space technology, space simulation chamber, food preservation and industrial applications, nuclear propulsions, chemical propulsions.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Demonstrate the characteristics of the cryogenic fluid and the challenges acquiredin achieving it.

CO2. Explain the working of in various measurement systems used in Cryogenics.

CO3. Explain the importance of cryogenic insulations.

CO4. Explain the hazard waste management and superconductive devices.

CO5. Obtain ideas in the various applications of cryogenic systems

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	-	-	-	-	2	2	-	2	2	-	2	1	2	-
CO2	2	-	-	-	2	3	2	-	-	-	-	-	1	2	2
CO3	2	-	2	-	2	2	3	-	2	-	-	2	-	-	-
CO4	2	-	-	-	2	-	-	-	-	-	-	-	-	-	-
CO5	2	-	-	-	2	-	-	-	2	-	-	2	2	-	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Cryogenic process engineering Timmerch and & Flynn Springer 1989.

2. Cryogenic Fundamentals, G.G. Haselden, Academic Press. New York, 1972.

3. Cryogenic Systems, Randall. F.Barron, Oxford University Press second edition, 1989.

REFERENCE BOOKS:

1. Cryogenics: Applications and Progress, A. Bose and P. Sengupta, Tata McGraw Hill.
2. Handbook of Cryogenic Engineering, Editor – J.G. Weisend II, Taylor and Francis
3. Cryogenic Process Engineering, K.D. Timmerhaus and T.M. Flynn, Plenum Press.
4. Advanced Cryogenics, Editor – C.A. Bailey, Plenum Press.
5. Applied Cryogenic Engineering, Editors – R.W. Vance and W.M. Duke, John Wiley & sons.

WEB RESOURCES:

1.Introduction to Cryogenic Engineering: https://nptel.ac.in/courses/112101004

AE606405- REMOTE SENSING CONCEPTS

Course Category: Vertical 4	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To familiarize about the basic principles of remote sensing
- To acquire knowledge about the motion of remote sensing satellites in the space
- To expose the various types of sensors used for remote sensing
- To gain knowledge about the generation of satellite data products
- To extract useful information from satellite images

UNIT 1: PHYSICS OF REMOTE SENSING **9**

Remote Sensing - Defintion - Components - Electro Magnetic Spectrum – Basic wave theory – Particle theory – Stefan Boltzman law - Wiens-Displacement Law - Radiometric quantities - Effects of Atmosphere-Scattering – Different types –Absorption-Atmospheric window- Energy interaction with surface features – Spectral reflectance of vegetation, soil and water –atmospheric influence on spectral response patterns- multi concept in Remote sensing.

UNIT 2: PLATFORMS **9**

Orbit elements – Types of orbits – Motions of planets and satellites – Launch of space vehicle – Orbit perturbations and maneuvers – escape velocity - Types and characteristics of different remote sensing platforms – sun synchronous and geo synchronous satellites.

UNIT 3: SENSORS	9

Classification of remote sensors – selection of sensor parameters - resolution concept - Spectral, Radiometric and temporal resolution – Quality of images – imaging mode – photographic camera – opto-mechanical scanners – pushbroom and whiskbroom cameras – Panchromatic, multi spectral , thermal, hyperspectral scanners and microwave sensors – geometric characteristics of scanner imagery – Operational Earth resource satellites - Landsat, SPOT, IRS, World View, hyperion and hysis, ERS, ENVISAT, Sentinel.

UNIT 4: DATA RECEPTION AND DATA PRODUCTS	9

Ground segment organization – Data product generation – sources of errors in received data – referencing scheme – data product output medium – Digital products – Super structure, Fast, Geo TIFF, Hierarchical and HDF formats – Indian and International Satellite Data Products – ordering of data.

UNIT 5: DATA ANALYSIS	9

Data products and their characteristics – Elements of visual interpretation – interpretation keys – Digital image processing – Preprocessing – Image rectification – Image enhancement techniques– Image classification – Supervised and unsupervised classification algorithms for multispectral and hyperspectral images – Accuracy assessment.- hybrid classification techniques – Knowledge based classification, Neural Network Classification, Fuzzy Classification.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1:Understand the concepts and laws related to remote sensing

CO2:Acquire knowledge about various remote sensing platforms

CO3:Understand the characteristics of different types of remote sensors

CO4:Gain knowledge about reception, product generation, storage and ordering of satellite data

CO5:Understand the concept of different image processing techniques and interpretation of satellite data

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	-	3	-	-	-	-	-	-	-	-	2	2	-	-
CO2	-	3	-	2	-	-	-	-	2	-	-	-	-	2	1
CO3	2	-	3	-	-	-	-	-	-	-	-	2	2	-	-
CO4	2	-	-	2	3	-	-	-	-	-	-	-	-	-	-
CO5	-	3	-	-	-	-	-	-	-	-	-	-	-	-	

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Lillesand T.M., and Kiefer,R.W. Remote Sensing and Image interpretation, VI edition of John Wiley & Sons-2015.

2. John R. Jensen, Introductory Digital Image Processing: A Remote Sensing Perspective, 4th Edition, 2015.

3. John A.Richards, Springer – Verlag, Remate Sensing Digital Image Analysis 5th edition, 2013.

REFERENCE BOOKS:

1. Paul Curran P.J. Principles of Remote Sensing, ELBS; 1985.

2. George Joseph, Fundamentals of Remote Sensing, Third Edition, Universities Press (India) Pvt Ltd, Hyderabad, 2018

3. Verbyla, David, Satellite Remote Sensing of Natural Resources. CRC Press, 1995
4. Basudeb Bhatta, Remote Sensing and GIS, Oxford University Press, 2011
WEB RESOURCES:
1.Remote Sensing: https://nptel.ac.in/courses/105108077

AE606406 MISSILE GUIDANCE AND CONTROL						
Course Category: Vertical 4	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To study the concepts of navigation.
- To learn the basic concepts of missile guidance.
- To learn various guidance laws.
- To understand the missile autopilot system.
- To learn various missile control methods.

UNIT 1: CONCEPTS OF NAVIGATION	**9**
Introduction Concepts of navigation, guidance and control. Introduction to basic principles. Air data information. Radar Systems Principle of working of radar. MTI and Pulse Doppler radar. Moving target detector. Limitation of MTI performance. MTI from a moving platform (AMTI).	
UNIT 2: MISSILE GUIDANCE	**9**
History of Guided Missile for Air Defence Applications - Classification of Missiles-Tactical Missile Description-Fundamentals of Guidance - Basic Results in Interception and Avoidance Taxonomy of Guidance Laws, Command and Homing Guidance Classical Guidance Laws - Pursuit, LOS,CLOS, BR, Proportional Navigation and Its Variants Like PPN, BPN, APN, TPN, GPN and IPN.	
UNIT 3: MODERN GUIDANCE LAWS	**9**
Modern guidance Laws-Guidance Laws Derived from Optimal Control Theory and Lyapunov method - PPN with Non-Manoeuvring and Manoeuvring Targets–Qualitative analysis. Comparative Study of Guidance Laws from the Point of View of Time, Miss-Distance, Launch Boundaries, Control Effort and Implementation Difficulties.	
UNIT 4: MISSILE AUTOPILOTS	**9**
Missile Autopilots - Flight Control System-Pitch, Yaw and Roll Autopilot - Control Surfaces Autopilot Commands - Dither Adaptive Control-lnertial Reference Adaptive Control. Functional Block Diagram-Angle Tracking and Seeker Head Stabilization-Radom Refraction Aerodynamics for Autopilot Design.	
UNIT 5: MISSILE CONTROL METHODS	**9**
Missile Control Methods -Optimal Filtering- Simulations. Formulation of optimal control for performance of aerospace systems-Riccatti equations-Performance measure-Optimal mid-course guidance.	

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Explain the concepts of navigation.

CO2: Understand the basic concepts of missile guidance.

CO3: Explain various guidance laws.

CO4: Understand the missile autopilot system

CO5: Identify the suitable missile control method.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	3	2	-	-	-	-	-	-	-	-	2	-	-
CO2	3	3	3	2	-	1	-	1	1	1	1	2	1	-	-
CO3	3	3	2	2	2	-	1	-	-	-	1	-	2	1	1
CO4	3	3	2	2	2	1	1	-	1	-	-	1	2	-	1
CO5	3	3	3	2	2	1	1	-	-	1	1	1	2	1	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. George M. Siouris, 'Missile Guidance and Control Systems', Springer Verlag , New York Inc., 2004.

2. Paul Zarchan , 'Tactical and Strategic Missile Guidance', AIAA, Inc., Sixth Edition, 2012.

3. N.A. Shneydor, 'Missile Guidance and Pursuit: Kinematics, Dynamics and Control', Ellis Horwood Publishers, 1998.

REFERENCE BOOKS:

1. Eichblatt E. J. , 'Test and Evaluation of the Tactical Missiles', AIAA Inc, 1989.

2. Ching-Fang-Lin, 'Modern Navigation, Guidance and Control Processing', Prentice- Hall, Inc., Englewood Cliffs, New Jersey, 1991.

3. R. Yanushevsky, 'Modern Missile Guidance', CRC Press, 2008.

4. P. Garnell, 'Guided Weapon Control Systems', Second Edition, Brassey'sDefence Publishers, London, l987.

WEB RESOURCES:

1.Guidance of Missiles: https://archive.nptel.ac.in/courses/101/108/101108054/

AE606407- CHEMICAL ROCKETS						
Course Category: Vertical 4	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- Understand the concepts of Chemical rockets.
- Identify and interpret the factors affecting the ignition energy release and its mechanism for any given ignition source.
- Judge the type of igniters to be designed for any chemical rocket propulsion system.
- Generate the sufficient information about the flame spreading and its mechanism in solid rocket motor.
- Assess the knowledge of solid propellant extinction in the designing process of a solid rocket motor.

UNIT 1: INTRODUCTION	**9**
Propellant Selection - Equation of State, Equilibrium, Entropy Principle, Equilibrium Conditions. Chemical Potential- Reacting Systems Versus Non-reacting Systems, Chemical Potential and Equilibrium, Evaluation of Chemical Potential. Iteration Equations - Lagrange Multipliers, Newton-Raphson Method, Constant Pressure Systems, Reduced Iteration-Equations.	
UNIT 2: IGNITION & FACTORS AFFECTING IGNITION ENERGY	**9**
Introduction; Process of Self- ignition; Induction Period; Limits of Self-ignition; Forced ignition; Basic Idea of Ignition by Spark; Pilot Flames; Hot Gases and Shock Waves; Effect of Composition, Type of Electrode, Spark Duration, Pressure, Temperature, Diluents, Effect of Mixture Velocity and Turbulence on Ignition Energy.	
UNIT 3: IGNITERS FOR CHEMICAL ROCKET	**9**
Igniters for Solid Rocket Motors – Role and Requirements; Classification of Igniters based on Mounting Locations and Energy Release Systems; Construction and Initiation Systems; Hardware Components; Design of Pyrotechnic and Pyrogen Igniters; Testing and Evaluation; Igniters for Liquid Propellant Engines, Hypergolic Ignition and Ignition Delay; Catalyst Induced Ignition;	
UNIT 4: FLAME SPREADING AND IGNITION TRANSIENT	**9**
Physical Processes during Ignition Transient; Ignition Transient Models and Experiments; Flame Spreading over Solid Propellants, Fuels, Defects and Cracks.	
UNIT 5: EXTINCTION	**9**
Controlled Termination of Thrust – Approaches; Energy Balance at Burning Surface; Dynamic Extinction by Fast Depressurization, Fast Deradiation and other Quenching Techniques, like Injection of Flame Inhibitors, Heat Sink, etc.; Theories and Experiments of Extinction.	
	TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to
CO1: Explain the basics of Chemical rockets.
CO2: Interpret different types of igniters and its applications in the propulsion system.
CO3: Design an igniter for the given chemical rocket propulsion system for the given thrust range.
CO4: Describe the concept of flame spreading and ignition transient in a solid rocket motor.
CO5: Predict the various mechanism of extinction utilized in the solid rocket motor along with their advantages and disadvantages.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	3	2	-	-	-	-	-	-	-	-	2	-	-
CO2	3	3	3	2	-	-	-	-	-	-	-	2	-	-	
CO3	3	2	1	2	-	-	-	-	1	1	1	1	2	2	1
CO4	3	2	1	2	1	1	1	-	-	-	-	1	2	-	1
CO5	3	3	3	2	1	1	1	-	1	1	1	1	2	2	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Holman,J.P., "Heat Transfer", McGraw Hill Book Co.,Inc., New York, Sixth Edition,1991.

2. Sachdeva,S.C., "Fundamentals of Engineering Heat and Mass Transfer", Wiley Eastern Ltd., New Delhi,1981.

3. Yunus,A.Cengel, "Heat Transfet-A Practical Approach", Tata McGraw Hill, Second edition, 2003.

4. E Rathakrishnan, "Elements of Heat Transfer", Taylor and Francis, CRC Press, 2012.

REFERENCE BOOKS:

1. Lienhard,J.H., A Heat Transfer Text Book, Prentice Hall Inc., 1981.

2. Mathur,M. and Sharma,R.P., Gas Turbine and Jet and Rocket Propulsion, Standard Publishers, New Delhi, 1988.

3. Sutton,G.P., Rocket Propulsion Elements,John Wiley and Sons, Fifth Edition, 1986

WEB RESOURCES:

1.Introduction to Rocket Propulsion: https://nptel.ac.in/courses/101104078

AE606408 - LAUNCH VEHICLE TECHNOLOGY

Course Category: Vertical 4	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To compute and analyze the various forces and moments acting on a rocket.
- To formulate the equations of motions for flight and separation phases
- To understand the combustion and propulsion systems in rocket
- To select suitable materials for the rockets and launch vehicles.
- To understand the design, performance and testing aspects.

UNIT 1ROCKET DYNAMICS **9**

Classification of launch vehicles and missiles – Rocket systems – Airframe components – Forces and moments acting on a rocket – Propulsion, aerodynamics, gravity – inertial and non-inertial frames – coordinate transformation – Equations of motion for three-dimensional motion through atmosphere and vacuum – numerical problems.

UNIT 2: SOLID PROPULSION AND PYROTECHNICS **9**

Solid propellant rockets – classification – components and their design considerations – propellant grain design – grain mechanical properties – ballistics and burn rate design issues – igniter design – pyrotechnic devices and systems – classification – mechanisms and application of pyrotechnic devices in rockets and launch vehicles – Design problems in rocket systems.

UNIT 3: LIQUID PROPULSION AND CONTROL SYSTEMS **9**

Liquid propellant rockets – classification and components – thrust chamber, feed systems, propellant tanks, turbo-pumps, types of valves and applications – their design considerations – Different bipropellant systems like cryogenics and their characteristics – pogo and slosh engine gimbal systems and thrusters for control – Thrust control systems – Design problems

UNIT 4: MULTI-STAGING OF ROCKET AND SEPARATION DYNAMICS **9**

Navigation and guidance systems in rockets and launch vehicles – aerodynamic control systems of launch vehicles – multi-staging of rockets – vehicle optimization techniques –stage separation system – dynamics, separation techniques – rocket flight dispersion, numerical problems.

UNIT 5: DESIGN, MATERIALS AND TESTING OF ROCKETS **9**

Design requirements and selection – performance evaluation and assessment – space environment on the selection of materials for rockets and spacecraft – material selection for specific requirements – advance materials-super alloys and composite materials –Qualification of rocket and missile systems – types of testing and evaluation of design and function.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Learn about the different systems of rockets and launch vehicles, formulation of the equation of motion and about the advanced rockets for future missions

CO2: Understand the function of the solid propellant propulsion and pyrotechnic systems and the design principles.

CO3: Understand the function of the liquid propellant propulsion and control systems and the design principles

CO4: Formulate the equation of motions for a mission and spent stage separation dynamics, understanding the principles of navigation, guidance and control of rockets and launch vehicles, and design of a multistage rocket

CO5: Understand the system design, construction, function, performance and testing aspects and to familiarize with the selection of suitable materials for different rocket systems.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	1	2	1	-	-	-	1		1	2	1	-
CO2	3	2	1	1	2	1	-	-	-	1		1	2	1	-
CO3	3	2	1	1	2	1	-	-	-	1		1	2	1	-
CO4	3	2	1	1	2	1	-	-	-	1		1	2	1	-
CO5	2	1	1	-	1	1	-	-	-	-		1	2	1	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Cornelisse, J. W., "Rocket Propulsion and Spaceflight Dynamics", Pitman, London, 1982

2. Ramamurthi K., "Rocket Propulsion", Macmillan Publishers India first Ed., 2010.

3. Sutton, G.P., "Rocket Propulsion Elements", John Wiley & Sons; 8th Edition 2010

REFERENCE BOOKS:

1. George M. Siouris, "Missile Guidance and Control Systems", Springer-Verlag New York, 2004

2. Joseph Jimmerson, "The Rocket Files", Lulu.com, 2nd Ed., 201

WEB RESOURCES:

1. https://www.slideshare.net/NEERAJSHARMA814/launching-vehicles

AE606409 COMBUSTION THEORY						
Course Category: Vertical 4	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- Comprehend the basic concepts of combustion
- Acquire the knowledge of chemical kinetics and flames in combustion
- To understand the combustion in gas turbine engines.
- Understand the combustion process for various propellants and fuels in rocket
- To learn about the supersonic combustion in supersonic speeds.

UNIT 1:INTRODUCTION TO COMBUSTION **9**

Classification of launch vehicles and missiles – Rocket systems – Airframe components – Forces and moments acting on a rocket – Propulsion, aerodynamics, gravity – inertial and non-inertial frames – coordinate transformation – Equations of motion for three-dimensional motion through atmosphere and vacuum – numerical problems.

Thermo-chemical equations –Heat of formation –Activation energy -Multi-step reactions - Heat of reaction -first order, second order and third order reactions – Calculation of adiabatic flame temperature

UNIT 2: BASICS OF CHEMICAL KINETICS AND FLAMES **9**

Premixed flames –Diffusion flames –measurement of burning velocity – various methods –Effect of various parameters on burning velocity – flame stability –Deflagration – Detonation – Rankine- Hugoniot curve –Radiation by flames.

UNIT 3: COMBUSTION IN GAS TURBINE ENGINES **9**

Combustion in gas turbine combustion chambers -Recirculation – combustion efficiency, Factors affecting combustion efficiency-Fuels used for gas turbine combustion chambers – combustion stability –Flame holder types.

UNIT 4: COMBUSTION IN ROCKETS **9**

Solid propellant grain types – types of solid propellant burning in rocket combustion chambers – basic mechanism of composite propellant combustion – solid propellant burn rate laws – criterion for stable combustion - combustion in liquid rocket engines – single fuel droplet combustion model – combustion in hybrid rockets

UNIT 5: SUPERSONIC COMBUSTION **9**

Introduction – supersonic combustion controlled by diffusion, mixing and heat convection – Analysis of reactions and mixing processes - supersonic burning with detonation shocks.

TOTAL : 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: To evaluate the different systems of rockets and launch vehicles, formulation of the equation of motion and about the advanced rockets for future missions

CO2: To analyse and impart the combustion processes.

CO3: To evaluate the detailed mechanism of combustion Aircraft engines.

CO4: To analyse the detailed mechanism of combustion in rockets.

CO5: To analyse and impart the supersonic combustion processes.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	1	2	1	-	-	-	1	-	1	2	1	-
CO2	3	2	1	1	2	1	-	-	-	1	-	1	2	1	-
CO3	3	2	1	1	2	1	-	-	-	1	-	1	2	1	-
CO4	3	2	1	1	2	1	-	-	-	1	-	1	2	1	-
CO5	2	1	1	-	1	1	-	-	-	-	-	1	2	1	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Sharma, S.P., and Chandra Mohan, "Fuels and Combustion", Tata Mc. Graw Hill Publishing Co., Ltd., New Delhi, 1987.

REFERENCE BOOKS:

1. Beer, J.M., and Chiierar, N.A. "Combustion Aerodynamics", Applied Science Publishers Ltd., London, 1981.

2. Chowdhury, R., Applied Engineering Thermodynamics, Khanna Publishers, New Delhi, 1986.

3. Loh, W.H.T., "Jet, Rocket, Nuclear, Ion and Electric Propulsion: Theory and Design, Springer Verlag, New York, 1982.

WEB RESOURCES:

1https://archive.nptel.ac.in/courses/112/106/112106299/

AE 606410 ROCKET PROPULSION						
Course Category: Vertical 4	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To make students understand the basic operating principle of rocket propulsion.
- To make students understand the parameter required to estimate the performance of rockets
- To impart knowledge to students on different types of rocket propulsion systems
- To learn the concepts of rocket propulsion applications areas and disadvantages
- To expose the students on the methods of multi-staging of rocket vehicles and on the technologies for rocket control using aerodynamic and jet control means

UNIT 1: INTERNAL BALLISTICS OF ROCKETS	**9**

Reaction principle – Rocket performance parameters – specific impulse – Schematic diagrams of solid, liquid and hybrid rocket propulsion systems – Equilibrium chamber pressure – Thrust equation – Characteristic velocity and thrust coefficient – Rocket performance assessment

UNIT 2: SOLID ROCKET PROPULSION	**9**

Selection criteria of solid propellants – Types of solid propellants – Propellant ingredients – Solid propellant regression rate and factors influencing the regression rate – Solid propellant grain configurations – Progressive, regressive and neutral burning of grains- Solid rocket igniters – Basics of solid propellant combustion and combustion instability – Erosive burning – Pressure and regression rate relationship

UNIT 3: LIQUID ROCKET PROPULSION	**9**

Types of liquid propellant combinations – Gas pressure and turbopump fed pressurization systems for liquid propellant rockets – Liquid rocket injectors and water testing – Liquid rocket cooling methods – Basic aspects of thrust chamber design - Thrust control – Advantages of liquid rockets over solid rockets – Combustion instability – Cryogenic rocket engines – Propellant slosh.

UNIT 4: HYBRID ROCKET PROPULSION	**9**

Standard and reverse hybrid systems – Combustion mechanism in hybrid rockets –Limitations and applications of hybrid rockets – Solid grain configurations in hybrid rockets-Solid grain regression rate behavior along the grain length - Local regression rate estimation – Material combinations for hybrid rocket propellants- Estimation of hybrid rocket performance – Performance comparison with solid and liquid rocket systems

UNIT 5: STAGING AND STEERING OF ROCKETS	**9**

Need for multi-staging of rocket vehicles – different types of multi-staging - staging optimization methods – estimation of staging performance – stage separation methods in atmosphere and in space -steering methods for rockets – aerodynamic control based steering – types – merits and limitations – jet control based steering – thrust vector control methods – merits and limitations of these methods

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Will explain the basic principles and develop interest to join aerospace industry as a scientist/engineer

CO2: Will be able to develop skills and apply them for conceptual designs of rocket propulsion systems as a design team member

CO3: Will be able to evaluate the performance parameters of rocket propulsion systems and can suggest alternate designs if needed

CO4: Will be able to describe the advanced technology concepts like cryogenic rocket technology and be able to create preliminary designs of solid-cryogenic multi-stage configurations

CO5: Will be able to adapt himself/herself to aerospace industry by the acquired knowledge and apply skills in the preliminary design of rocket subsystems

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	1	2	1	-	-	-	1		1	2	1	-
CO2	3	2	1	1	2	1	-	-	-	1		1	2	1	-
CO3	3	2	1	1	2	1	-	-	-	1		1	2	1	-
CO4	3	2	1	1	2	1	-	-	-	1		1	2	1	-
CO5	2	1	1	-	1	1	-	-	-	-		1	2	1	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. David H. Heiser and David T. Pratt., "Hypersonic Air breathing Propulsion", AIAA Education Series, 1999.

2. Mathur, M.L. and Sharma, R.P., "Gas Turbine, Jet and Rocket Propulsion", Standard Publishers & Distributors, Delhi, 2nd edition 2014.

3. Sutton, G.P., "Rocket Propulsion Elements", John Wiley & Sons; 8th Edition 2010

REFERENCE BOOKS:

1. Martin J. Chiaverini and Kenneth K. Kuo, "Fundamentals of Hybrid Rocket Combustion and Propulsion", Progress in Astronautics and Aeronautics, 2007.

2. Ramamurthi K, "Rocket Propulsion", Macmillian publishers India Ltd, 1st edition, 2010.

WEB RESOURCES:

1.https://archive.nptel.ac.in/courses/101/104/101104078/

Vertical-5

AIRCRAFT MAINTENANCE

CURRICULUM

S. No.	Course Code	Course Title	Classification		L	T	P	C
1	AE606501	Airframe maintenance and repair	PE	Theory	3	0	0	3
2	AE606502	Aircraft general engineering and maintenance and practices.	PE	Theory	3	0	0	3
3	AE606503	Civil aviation regulations	PE	Theory	3	0	0	3
4	AE606504	Air traffic control (NPTEL)	PE	Theory	3	0	0	3
5	AE606505	Aircraft Engine maintenance and Repair	PE	Theory	3	0	0	3
6	AE606506	Aircraft Overhauling	PE	Theory	3	0	0	3
7	AE606507	Sensors and Instrumentation (NPTEL)	PE	Theory	3	0	0	3
8	AE606508	Helicopter Maintenance (NPTEL)	PE	Theory	3	0	0	3
9	AE606509	Air transportation and aircraft Maintenance Engineering	PE	Theory	3	0	0	3

AE606501 AIRFRAME MAINTENANCE AND REPAIR					
Course Category: Vertical 5	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Acquire knowledge on welding and sheet metal repair operations and maintenance practices in aviation industry
- Gain knowledge on maintenance and repair procedures on plastics and composite structures
- Understand the Assembly & Rigging procedures and operation of Helicopter flight controls.
- Learn the inspection and maintenance of major and auxiliary systems
- Appreciate the procedure of Troubleshooting & safety practices

UNIT 1: MAINTENANCE OF AIRCRAFT **9**

Rules and Regulations for Civil Aviation in India, Indian aircraft rules, Civil aviation requirement, CAR 66, Aircraft System, Ensuring quality welds - Welding jigs and fixtures - Soldering and brazing – laser welding. Sheet metal repair and maintenance: Selection of materials; Tools - power/hand; Repair techniques; Peening - Close tolerance fasteners; Sealing compounds; forming/shaping; Calculation of weight of completed repair; Effect of weight - change on surrounding structure. Sheet metal inspection - N.D.T. Testing. Riveted repair design - Damage investigation - Reverse engineering.

UNIT 2: PLASTICS AND COMPOSITES IN AIRCRAFT **9**

Review of types of plastics used in airplanes - Maintenance and repair of plastic components - Repair of cracks and holes - various repairs schemes - Scopes. Cleaning of fibre reinforced plastic (FRP) materials prior to repair; Break test - Repair Schemes; FRP/honeycomb sandwich materials; laminated FRP structural members and skin panels; Tools/equipment; Vacuum-bag process. Special precautions – Autoclaves.

UNIT 3AIRCRAFT JACKING, ASSEMBLY AND RIGGING **9**

Airplane jacking and weighing and C.G. Location. Balancing of control surfaces - Inspection maintenance. Helicopter flight controls. Tracking and balancing of main rotor. Aircraft Electrical System, Inspection of Aircraft and Basic Aircraft Design.

UNIT 4: REVIEW OF HYDRAULIC AND PNEUMATIC SYSTEM **9**

Trouble shooting and maintenance practices - Service and inspection - Inspection and maintenance of landing gear systems. Aircraft Fuel System, Aircraft Wheels, Aircraft Brakes System- Inspection and maintenance of air-conditioning and pressurization system, water and waste system. Installation and maintenance of Instruments - handling - Testing - Inspection. Inspection and maintenance of auxiliary systems - Rain removal system - Position and warning system - Auxiliary Power Units (APUs).

UNIT 5: SAFETY PRACTICES **9**

Hazardous materials storage and handling, Aircraft furnishing practices - Equipments. Trouble shooting. Theory and practices. Maintenance Schedule, inspection of cessna 206.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student Will be able to

CO1:Identify and apply the principles of function and safe operation to aircraft as per FAA

CO2: Evaluate general airframe structural repairs, the structural repair manual and structural control

programme

CO3: Know about aircraft adhesives, sealants, bonding techniques, repair procedures and the types and detection of defects in aircraft composite materials

CO4: Identify, install, inspect, fabricate and repair aircraft sheet metal and synthetic, material structures.

CO5: Understand the procedure of Troubleshooting & safety practices

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	2	2	2	-	-	-	-	1	-	2	-	3	3
CO2	3	3	1	2	1	-	-	-	-	1	-	2	-	3	2
CO3	3	2	2	1	2	1	1	-	-	-	1	1	2	2	1
CO4	3	2	1	-	1	-	-	2	-	-	1	1	2	1	1
CO5	3	3	2	1	2	1	-	2	1	1	2	2	2	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Kroes, Watkins, Delp, "Aircraft Maintenance and Repair", McGraw Hill, New York, 1992

REFERENCE BOOKS:

1Brimm D.J. Bogges H.E., "Aircraft Maintenance", Pitman Publishing corp., New York, 1940

2Delp. Bent and Mckinely "Aircraft Maintenance Repair", McGraw Hill, New York, 1987.

3. Larry Reithmeir, "Aircraft Repair Manual", Palamar Books, Marquette, 1992..

WEB RESOURCES:

1. https://www.slideshare.net/DeepanBooramurthy/airframe-maintenance-and-repair.

AE606502 AIRCRAFT GENERAL ENGINEERING AND MAINTENANCE AND PRACTICES

Course Category: Vertical 5	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To familiarize with ground handling of aircraft, Engine starting procedures and special procedures such as Mooring, jacking, levelling and towing operations
- To familiarize with ground servicing of Air conditioning and pressurization systems
- To familiarize with Shop safety and Environmental cleanliness.
- To familiarize with FAA airworthiness regulations and check list involved in each inspection of

aircraft

- To familiarize with terminology involved in aircraft hardware selection, identification of fluid line fittings.

UNIT 1: AIRCRAFT GROUND HANDLING AND SUPPORT EQUIPMENT	**9**
Mooring, jacking, levelling and towing operations – Preparation – Equipment - precautions – Engine starting procedures – Piston engine, turboprops and turbojets – Engine fire extinguishing – Ground power units.	
UNIT 2:GROUND SERVICING OF VARIOUS SUB SYSTEMS	**9**
Ground movement of aircraft –Tie down procedures –Taxiing aircraft - Air conditioning and cabin pressurization – Oxygen and oil systems – Fuel servicing and De fuelling- Ground support equipment and their maintenance.	
UNIT 3: MAINTENANCE OF SAFETY	**9**
Shop safety – safety around compressed gases - Hazardous materials- Machine Tools – Flight Line safety – Foreign Object Damage (FOD)-Fire extinguishers-Classes- Identifications-Environmental cleanliness – Precautions.	
UNIT 4: INSPECTION	**9**
Process – Purpose – Types – Inspection intervals – Techniques – Checklist – Special inspection – Publications, bulletins, various manuals – FAR Air worthiness directives – Type certificate Data sheets – ATA Specifications	
UNIT 5AIRCRAFT HARDWARE, MATERIALS, SYSTEM PROCESSES	**9**
Hand tools – Precision instruments – Special tools and equipments in an airplane maintenance shop Identification terminology – Specification and correct use of various aircraft hardware (i.e. nuts, bolts, rivets, screws etc) – American and British systems of specifications – Threads, gears, bearings, etc – Drills, tapes and reamers – Identification of all types of fluid line fittings. Materials, metallic and non metallic Plumbing connectors – Cables – Swaging procedures, tests, Advantages of swaging over splicing.	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student Will be able to	
CO1: Gained Knowledge in various ground support system for aircraft operations	
CO2: Ability to carry out ground servicing of critical aircraft systems	
CO3: Understand the ground handling procedures and types of equipments with special maintenance .	
CO4: Ability to do shop safety, Environment cleanliness in an aircraft materials shop	
CO5: Understand the FAA airworthiness regulations and the checklist involved in each inspection of aircraft	

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	3	2	-	-	-	-	-	-	-	-	2	-	-
CO2	3	3	3	2	-	1	-	1	1	1	1	2	1	-	
CO3	3	3	2	2	2	-	1	-	-	-	1	-	2	1	1
CO4	3	3	2	2	2	1	1	-	1	-	-	1	2	-	1
CO5	3	3	3	2	2	1	1	-	-	1	1	1	2	1	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Michael J.Kroes, William A.Watkins ad Frank Delp, "Aircraft Maintenance and Repair", Tata McGraw Hill Education Private Limited, Seventh Edition, New Delhi, 2013.

2. KROES WATKINS DELP, "Aircraft Maintenance and Repair" – McGraw-Hill, New York 1993.

REFERENCE BOOKS:

1. Airframe and Power plant Mechanics, "Aircraft hand Book" Federal Aviation Administration, Shroff publishers and distributors Pvt. Ltd. New Delhi 2010.

2. A & P MECHANICS, "Aircraft hand Book" – F. A. A. Himalayan Book House, New Delhi, 1996.

3. Airframe and Power plant Mechanics, "General hand Book" Federal Aviation Administration, Shroff publishers and distributors Pvt. Ltd. New Delhi 2010.

WEB RESOURCES:

1.https://www.iare.ac.in/sites/default/files/lecture_notes/AME_LECTURE_NOTES.pdf

AE606503 CIVIL AVIATION REGULATIONS					
Course Category: Vertical 5	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To acquaint students with airworthiness regulations and civil air worthiness requirements
- To familiarize students with analytical study of in- flight readings and engine reliability programmes and aircraft maintenance programmes
- To impart knowledge on procedures relating to registration of aircraft, issue and renewal of air worthiness certificates to aircraft.
- To acquaint students with aircraft maintenance engineer licensing procedures
- To make the students learn weight and balance control of an aircraft and material and documents to be carried on board for Indian registered aircraft.

UNIT 1: Indian aircraft rules 1937 and related publications **9**

Knowledge of aircraft act, 1934, aircraft rules, 1937 as far as they related to airworthiness and safety of aircraft. Knowledge of civil airworthiness requirements, aeronautical information circulars, aeronautical information publications- (relating to airworthiness), advisory circulars & A.M.E. notices (NOTAMS) by DGCA.

UNIT 2: CAR: SERIES – A **9**

C.A.R. series A – procedure for issue of civil airworthiness requirements and responsibility of operators vis-à-vis air worthiness directorate Responsibilities of operators/owners; procedure of CAR issue, amendments etc; objectives and targets of airworthiness directorate; airworthiness regulations and safety oversight of engineering activities of operations C.A.R. series "B" – issue approval of cockpit check list, MEL, CDL: Deficiency list (MEL & CDL); preparation and use of cockpit check list and emergency check list.

UNIT 3: CAR -SERIES 'C' AND 'D' **9**

Defect recording, monitoring, investigation and reporting Defect recording, reporting, investigation, rectification and analysis; flight report, recording of in-flight instrument, reading and reporting of flight defects and rectification of defects observed on aircraft. Aircraft maintenance programs, Reliability programs (engines); aircraft maintenance programs& their approval: on condition maintenance of reciprocating engines; TBO – revision program

UNIT 4: C.A.R. SERIES E – APPROVAL OF ORGANIZATIONS: **9**

Approval of organizations in categories A, B, C, D, E, F, & G; requirements of infrastructure at stations other than parent base.

UNIT 5: C.A.R. SERIES "F" AIRWORTHINESS AND CONTINUED AIRWORTHINESS:	9

Procedure relating to registration of aircraft; procedure for issue / revalidation of type certification of aircraft and its engines / propellers; issue /revalidation and renewal of certificate of airworthiness; requirement for renewal of certificate of airworthiness. Suspensions of certificate of airworthiness and its subsequent revalidation.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student Will be able to

CO1: Acquire knowledge of Airworthiness requirements for transport, military, gliders and micro light aircrafts.

CO2: Perform defect recording, reporting, investigation, rectification and analysis.

CO3: Acquire Knowledge of procedure for holding examinations, proficiency checks etc.

CO4: Perform procedure relating to registration of aircraft and fulfil the requirements for grant of civil licenses.

CO5: Acquire Knowledge of Issue/validation and renewal of Certificate of Airworthiness and to determine airworthiness of ageing aircraft.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	-	3	-	-	-	-	-	-	-	-	2	2	-	-
CO2	-	3	-	2	-	-	-	-	2	-	-	-	-	2	1
CO3	2	-	3	-	-	-	-	-	-	-	-	2	2	-	-
CO4	2	-	-	2	3	-	-	-	-	-	-	-	-	-	-
CO5	-	3	-	-	-	-	-	-	-	-	-	-	-	-	

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Civil aviation requirements with latest amendment (section 2 airworthiness) – published by DGCA, the English book store, 17-l, Connaught circus, New Delhi. Aeronautical information circulars (relating to airworthiness) from DGCA.2009. Advisory circulars from DGCA,2009.

2."Civil Aviation Requirements with latest Amendment (Section 2 Airworthiness)" – Published by DGCA, The English Book Store, 17-1, Connaught Circus, New Delhi 2000.

REFERENCE BOOKS:

1. Aircraft manual (India) volume – latest edition, the English book store, 17-l, Connaught circus, New Delhi.2000.

WEB RESOURCES:

1.https://www.civilaviation.gov.in/sites/default/files/moca_000947.pdf

AE606504 AIR TRAFFIC CONTROL					
Course Category: Vertical 5	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To introduce the basic of air traffic control
- To impart knowledge about air traffic systems.
- To gain more knowledge on flight information systems.
- To learn about aerodrome data.
- To gain knowledge on navigation systems

UNIT 1: BASIC CONCEPTS	**9**

Objectives of air traffic control systems - Parts of ATC services – Scope and Provision of ATCs – VFR & IFR operations – Classification of ATS air spaces – Various kinds of separation – Altimeter setting procedures – Establishment, designation and identification of units providing ATS – Division of responsibility of control.

UNIT 2: AIR TRAFFIC SYSTEMS	**9**

Area control service, assignment of cruising levels - minimum flight altitude - ATS routes and significant points – RNAV and RNP – Vertical, lateral and longitudinal separations based on time / distance –ATC clearances – Flight plans – position report.

UNIT 3: FLIGHT INFORMATION SYSTEMS	**9**

Radar service, Basic radar terminology – Identification procedures using primary / secondary radar – performance checks – use of radar in area and approach control services – assurance control and co-ordination between radar / non radar control – emergencies – Flight information and advisory service – Alerting service – Co-ordination and emergency procedures – Rules of the air.

UNIT 4: AERODROME DATA	**9**

Aerodrome data - Basic terminology – Aerodrome reference code – Aerodrome reference point – Aerodrome elevation – Aerodrome reference temperature – Instrument runway, physical Characteristics; length of primary / secondary runway – Width of runways – Minimum distance between parallel runways etc. – obstacles restriction

UNIT 5: NAVIGATION AND OTHER SERVICES	**9**

Visual aids for navigation Wind direction indicator – Landing direction indicator – Location and characteristics of signal area – Markings, general requirements – Various markings – Lights, general requirements – Aerodrome beacon, identification beacon – Simple approach lighting system and various lighting systems – VASI & PAPI - Visual aids for denoting obstacles; object to be marked and lighter – Emergency and other services.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student Will be able to

CO1: Classify the requirement of air traffic control systems and types of air traffic control system

CO2: Explain in flight information systems and rules of air traffic systems.

CO3: Explore the emergency procedure and air rules followed by air traffic control systems..

CO4: Describe the aerodrome data.

CO5: Gain the information of navigation and emergency procedures in the air traffic control systems

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	2	1	-	-	-	-	-	-	-	-	-	2	-	-
CO2	1	3	-	-	3	-	-	-	-	-	-	-	3	1	-
CO3	1	3	1	1	1	-	-	-	-	-	-	-	3	1	-
CO4	1	2	-	2	3	-	-	-	-	-	-	-	2	-	-
CO5	1	1	1	-	-	-	-	-	-	-	-	-	3	1	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. AIP (India) Vol. I & II, "The English Book Store", 17-1, Connaught Place, New Delhi..

2Aircraft Manual (India) Volume I", Latest Edition – The English Book Store, 17-1, Connaught Place, New Delhi.

3."PANS – RAC – ICAO DOC 4444", Latest Edition, The English Book Store, 17-1, Connaught Place, New Delhi

REFERENCE BOOKS:

1. Michael S. Nolan., "Fundamentals of Air Traffic Control", Cengage Learning.

2. Wells .A-Airport Planning and Management, 4th Edition- McGraw-Hill, London-2000.

3. P S Senguttuvaan., "Fundamentals of Air Transport Management", McGraw-Hill, 2003.

WEB RESOURCES:

1. https://catsr.vse.gmu.edu/SYST460/CanadianATCStudyGuide.pdf

AE606505 AIRCRAFT ENGINE MAINTENANCE & REPAIR						
Course Category: Vertical 5	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To introduce fundamental aspects of piston engine maintenance and inspection procedures to students
- To acquaint students with damage assessment and balancing procedures of propeller
- To impart knowledge on various tools requirements and testing procedures of piston engine to students
- To familiarize students with jet engine maintenance, component inspection and damage criteria of engine components
- To impart knowledge on overhaul procedures and condition monitoring of the engine at various altitudes to students

UNIT 1: CLASSIFICATION OF PISTON ENGINE COMPONENTS &MAINTENANCE	**9**

Types of piston engines – Principles of operation – Functions of components – Materials – starting procedures of piston engines – Carburetors - Injection systems for small and large engines – Ignition system components – Spark plug details – Engine operating conditions at various altitudes – Maintenance and inspection check to be carried out- Inspection and maintenance and troubleshooting -Inspection of all engine components -Daily and routine checks-Overhaul procedures -Compression testing of cylinders

UNIT 2: INSPECTION AND REPAIRING OF PROPELLER	**9**

Propeller theory -operation, construction assembly and installation -Pitch change mechanism-Propeller axially system-Damage and repair criteria -General Inspection procedures -Checks on constant speed propellers -Pitch setting, Propeller Balancing, Blade cuffs, Governor/Propeller operating conditions –Damage and repair criteria

UNIT 3: ENGINE INSPECTION, TESTING AND REPAIR.	**9**

Symptoms of failure – Fault diagnostics – Case studies of different engine systems –Tools and equipment requirements for various checks and alignment during overhauling –Tools for inspection – Tools for safety and for visual inspection – Methods and instruments for non destructive testing techniques – Equipment for replacement of part and their repair. Engine testing: Engine testing procedures and schedule preparation – Online maintenance.

UNIT 4: GAS TURBINE ENGINE MAINTENANCE AND INSPECTION	**9**

Types of jet engines –Fundamental principles –Bearings and seals -Inlets -compressors-turbines-exhaust section –classification and types of lubrication and fuels-Materials used -Details of control, starting around running and operating procedures –Inspection and Maintenance-permissible limits of damage and repair criteria of engine components-internal inspection of engines-compressor washing-field balancing of compressor fans-Component maintenance procedures -Systems maintenance procedures -use of instruments for online maintenance -Special inspection procedures-Foreign Object Damage -Blade damage .

UNIT 5: ENGINE OVERHAULING AND TROUBLESHOOTING PROCEDURES	**9**

Engine Overhaul procedures – Inspections and cleaning of components – Repairs schedules for overhaul – Maintenance procedures of gas turbine engines – Trouble shooting and rectification procedures –

Components maintenance procedures – Systems maintenance procedures.-Balancing of Gas turbine components. Trouble Shooting - Procedures for rectification – Condition monitoring– engine health monitoring and corrective methods.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student Will be able to

CO1: Apply maintenance procedure to Aircraft Engines

CO2: Identify the engine components and faults

CO3: Apply non-destructive testing procedures to identify the defects

CO4: Apply overhauling procedure to new engines

CO5: Apply the compression testing of cylinders

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO2	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO3	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO4	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO5	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. KROES & WILD, "Aircraft Power plants", 8th Edition – McGraw Hill, New York, 2013.

2. Aircraft Inspection, Repair & Alterations 2013: Acceptable Methods, Techniques & Practices (FAA AC 43.13-1b and 43.13-2B) (FAA Handbooks Series) , ASA ,US DOT-2013.

REFERENCE BOOKS:

1. TURBOMECA, "Gas Turbine Engines", The English Book Store, New Delhi, 1993.

2. UNITED TECHNOLOGIES PRATT & WHITNEY, "The Aircraft Gas turbine Engine and its Operation", (latest edition) The English Book Store, New Delhi.

3. A&P Technician General Textbook - Jeppesen Edition: 4Publisher: Jeppesen Sanderson, Inc. ISBN-13: 9780884873396

WEB RESOURCES:

1.https://www.studocu.com/in/document/anna-university/be/aero-engine-maintenance-and-repair-notes-1/7926719

AE606506 AIRCRAFT OVERHAULING						
Course Category: Vertical 5	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

- To impart knowledge in the field of aircraft maintenance and ground control systems
- To obtain knowledge in the areas of propeller and its associated components.
- To enhance the practical knowledge in the areas of engine maintenance.

UNIT 1: PISTON ENGINES	**9**

Two and four stroke engines. Efficiency, factors affecting engine performance. Knowledge of the function and construction of various parts and accessories of the engine including induction, exhaust and cooling system, engine mounting. Engine fire detection and protection systems.

UNIT 2: PROPELLERS	**9**

Knowledge of purpose and functioning of parts of constant speed, variable pitch and feathering propellers and associated control system components.

UNIT 3: ENGINE FUEL AND OIL SYSTEM	**9**

Construction, features of carburetors, engine fuel and oil systems. Characteristics of aviation fuel and oil, common sources of contamination, methods of checking contamination. Ignition and starting systems: Magnetos and ignition system components, various types of engine starters

UNIT 4: ENGINE INSTRUMENTS	**9**

Principle of operation. Superchargers -constructional features and principles of operation and function of various types of superchargers and its related component.

UNIT 5: ENGINE MAINTENANCE	**9**

Piston/Gas Turbines: Periodical servicing procedures, engine installation checks, control rigging, ground running checks, priming, bleeding and performance checks. Engine on condition maintenance.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student Will be able to

CO1: Identify the engine and also able to categorize engine parts and other systems.

CO2: Understand the functioning of propellers.

CO3: Understand the features of fuel and oil systems in engine.

CO4: Gain practical exposure on engine instruments.

CO5: Gain practical exposure while servicing the engine.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	1	1	1	2	-	-	-	1	-	-	1	1	1	1
CO2	1	1	1	1	2	-	-	-	1	-	-	1	1	1	1
CO3	1	1	1	1	2	-	-	-	1	-	-	1	1	1	1
CO4	1	1	1	1	2	-	-	-	1	-	-	1	1	1	1
CO5	1	1	1	1	2	-	-	-	1	-	-	1	1	1	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS :

1.Michael J. Krose Thomas W.Wild, Bent, Aircraft Power Plants, 8 th edition McGraw Hill 2013

2. E Mangham and A Peace, Jet Engine Manual, Himalayan Books 1961.

3.Civil Aircraft Inspection Procedures (CAP 459), Himalayan Books vol I &II ,1981

REFERENCE BOOKS:

1.Jet Engines, Rolls Royce Ltd. 1996

2.Casamassa and Bent, Jet Aircraft Power Systems, Tata McGraw Hill

3.Pratt and Whitney, Gas Turbine Engine

WEB RESOURCES:

1.https://www.expaircraft.com/pdf/lycoming-oh-manual.pdf

2.https://www.aerospool.sk/downloads/RTC/AS-AMM-01-000_I1_R1_20180202.pdf

AE606507 SENSORS AND INSTRUMENTATION (NPTEL)

Course Category: Vertical 5	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

• To understand the concepts of measurement technology.

• To learn the various sensors used to measure various physical parameters.

• To learn the fundamentals of signal conditioning, data acquisition and communication systems used in mechatronics system development

• To learn about the optical, pressure and temperature sensor

• To understand the signal conditioning and DAQ systems

UNIT 1: INTRODUCTION **9**

Basics of Measurement – Classification of errors – Error analysis – Static and dynamic characteristics of transducers – Performance measures of sensors – Classification of sensors – Sensor calibration

techniques – Sensor Output Signal Types.

UNIT 2: MOTION, PROXIMITY AND RANGING SENSORS **9**

Motion Sensors – Potentiometers, Resolver, Encoders – Optical, Magnetic, Inductive, Capacitive, LVDT – RVDT – Synchro – Microsyn, Accelerometer – GPS, Bluetooth, Range Sensors – RF beacons, Ultrasonic Ranging, Reflective beacons, Laser Range Sensor (LIDAR)..

UNIT 3: FORCE, MAGNETIC AND HEADING SENSORS **9**

Strain Gage, Load Cell, Magnetic Sensors –types, principle, requirement and advantages: Magneto resistive – Hall Effect – Current sensor Heading Sensors – Compass, Gyroscope, Inclinometers.

UNIT 4: OPTICAL, PRESSURE AND TEMPERATURE SENSORS **9**

Photo conductive cell, photo voltaic, Photo resistive, LDR – Fiber optic sensors – Pressure – Diaphragm, Bellows, Piezoelectric – Tactile sensors, Temperature – IC, Thermistor, RTD, Thermocouple. Acoustic Sensors – flow and level measurement, Radiation Sensors - Smart Sensors - Film sensor, MEMS & Nano Sensors, LASER sensors.

UNIT 5: SIGNAL CONDITIONING AND DAQ SYSTEMS **9**

Amplification – Filtering – Sample and Hold circuits – Data Acquisition: Single channel and multi-channel data acquisition – Data logging - applications - Automobile, Aerospace, Home appliances, Manufacturing, Environmental monitoring

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student Will be able to

CO1: Recognize with various calibration techniques and signal types for sensors.

CO2: Describe the working principle and characteristics of force, magnetic, heading, pressure and temperature, smart and other sensors and transducers

CO3: Apply the various sensors and transducers in various applications.

CO4: Select the appropriate sensor for different applications..

CO5: Acquire the signals from different sensors using Data acquisition systems

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	-	-	-	-	-	-	-	-	-	-	-	2	1	-
CO2	1	2	2	2	2	-	-	-	-	-	1	-	2	1	-
CO3	1	2	2	2	2	-	-	-	-	-	1	-	2	1	-
CO4	1	2	2	2	2	-	-	-	-	-	1	-	2	1	-
CO5	1	2	2	2	2	-	-	-	-	-	1	-	2	1	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Ernest O Doebelin, "Measurement Systems – Applications and Design", Tata McGrawHill, 2009.

2. Sawney A K and Puneet Sawney, "A Course in Mechanical Measurements and Instrumentation and Control", Dhanpat Rai & Co, 12th edition New Delhi, 2013

3. C. Sujatha ... Dyer, S.A., Survey of Instrumentation and Measurement, John Wiley & Sons, Canada, 2001.

REFERENCE BOOKS:

1. Hans Kurt Tönshoff (Editor), Ichiro, "Sensors in Manufacturing" Volume 1, Wiley-VCH April 2001

2. John Turner and Martyn Hill, "Instrumentation for Engineers and Scientists", Oxford Science Publications, 1999.

WEB RESOURCES:

1.http://faculty.olin.edu/bstorey/isim.pdf

AE606508 HELICOPTER MAINTENANCE (NPTEL)

Course Category: Vertical 5	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the concepts of micro electromechanical devices
- To educate on the rudiments of Micro fabrication techniques
- To introduce the design concepts of micro sensors
- To know the design concepts of micro actuators
- To educate on the applications of MEMS to various disciplines

UNIT 1: HELICOPTER FUNDAMENTAL

Basic directions – Ground handling, Bearing – Gears.

UNIT 2: . MAIN ROTOR SYSTEM

Head maintenance – blade alignment – Static main rotor balance – Vibration – Tracking – Span wise dynamic balance – Blade sweeping –Electronic balancing – Dampener maintenance –Counter weight adjustment – Auto rotation adjustments – Mast & Flight Control Rotor - Mast – Stabilizer, dampeners – Swash plate flight control systems collective – Cyclic – Push pull tubes – Torque tubes – Bell cranks – Mixer box – Gradient unit control boosts – Maintenance & Inspection control rigging..

UNIT 3: MAIN ROTOR TRANSMISSIONS

Engine transmission coupling – Drive shaft – Maintenance clutch – Free wheeling units – Spray clutch – Roller unit – Torque meter – Rotor brake – Maintenance of these components – vibrations – Mounting systems – Transmissions.

UNIT 4: . POWER PLANTS & TAIL ROTORS

Fixed wing power plant modifications – Installation – Different type of power plant maintenance. Tail rotor system – Servicing tail rotor track – System rigging..

UNIT 5: AIRFRAMES AND RELATED SYSTEMS

Fuselage maintenance – Airframe Systems – Special purpose equipment.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student Will be able to

CO1: Understand the basic fundamentals of helicopter.

CO2: Identify the main rotor system components

CO3: Apply the main rotor transmissions on a helicopter

CO4: Apply the power plants and tail rotors maintenance.

CO5: Understand the airframe systems and its maintenance.

CO'S PO'S&PSO'S MAPPING

	PO 1	PO 2	PO 3	PO 4	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	-	-
CO 2	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-
CO 3	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-
CO 4	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-
CO 5	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Chang Liu, 'Foundations of MEMS', Pearson Education Inc., 2012.

2. Stephen D Senturia, 'Microsystem Design', Springer Publication, 2000.

3. Tai Ran Hsu, "MEMS & Micro systems Design and Manufacture" Tata McGraw Hill, New Delhi, 2002.

REFERENCE BOOKS:

1. Marc Madou, ―Fundamentals of Microfabrication‖, CRC press 1997.

2. Sergey Edward Lyshevski, ―MEMS and NEMS: Systems, Devices, and Structures‖ CRC Press, 2002

3. Nadim Maluf," An Introduction to Micro Electro Mechanical System Design", Artech House, 2000.

WEB RESOURCES:

1.https://linguisticstudentindonesia.files.wordpress.com/2020/08/helicopter-maintenance.pdf

2.https://www.bellcustomer.com/bulletins/download?filename=212inspection_and_airworthiness_limitations.pdf&categoryid=139

AE606509 AIR TRANSPORTATION AND AIRCRAFT MAINTENANCE ENGINEERING

Course Category: Vertical 5	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To introduce the basic of air transportation.
- To impart knowledge about airline economics.
- To gain more knowledge on airline scheduling
- To learn about aircraft reliability.
- To gain knowledge on aircraft maintenance

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UNIT 1: INTRODUCTION	9
ICAO – The general aviation industry airline – Factors affecting general aviation, use of aircraft, airport: airline management and organisation – levels of management, functions of management, Principles of organisation planning the organisation – chart, staff departments & line departments.	
UNIT 2: AIRLINE ECONOMICS	**9**
Forecasting – Fleet size, Fleet planning, the aircraft selection process, operating cost, passenger capacity, load factor etc. – Passenger fare and tariffs – Influence of geographical, economic & political factors on routes and route selection. Fleet Planning: The aircraft selection process – Fleet commonality, factors affecting choice of fleet, route selection and Capitol acquisition – Valuation & Depreciation – Budgeting, Cost planning – Aircrew evaluation – Route analysis – Aircraft evaluation	
UNIT 3: PRINCIPLES OF AIRLINES SCHEDULING	**9**
Equipment maintenance, Flight operations and crew scheduling, Ground operations and facility limitations, equipments and types of schedule – hub & spoke scheduling, advantages / disadvantages & preparing flight plans – Aircraft scheduling in line with aircraft maintenance practices.	
UNIT 4: AIRCRAFT RELIABILITY	**9**
Aircraft reliability – The maintenance schedule & its determinations – Condition monitoring maintenance – Extended range operations (EROPS) & ETOPS – Ageing aircraft maintenance production.	
UNIT 5: TECHNOLOGY IN AIRCRAFT MAINTENANCE	**9**
Airlines scheduling (with reference to engineering) – Product support and spares – Maintenance sharing – Equipments and tools for aircraft maintenance – Aircraft weight control – Budgetary control. On board maintenance systems – Engine monitoring – Turbine engine oil maintenance – Turbine engine vibration monitoring in aircraft – Life usage monitoring – Current capabilities of NDT – Helicopter maintenance – Future of aircraft maintenance.	
	TOTAL: 45 PERIODS
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Classify the requirement of air transportation organizationand various departments.	
CO2: Explain in airline economics and fleet planning.	
CO3: Explore the principles of airlines scheduling and ground operation.	
CO4: Describe the aircraft reliability.	
CO5: Gain the information about technology in aircraft maintenance.	

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO2	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-
CO3	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-
CO4	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-
CO5	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Chang Liu, 'Foundations of MEMS', Pearson Education Inc., 2012.

2. Stephen D Senturia, 'Microsystem Design', Springer Publication, 2000.

3. Tai Ran Hsu, "MEMS & Micro systems Design and Manufacture" Tata McGraw Hill, New Delhi, 2002.

REFERENCE BOOKS:

1. Marc Madou, ―Fundamentals of Microfabrication‖, CRC press 1997.

2. Sergey Edward Lyshevski, ―MEMS and NEMS: Systems, Devices, and Structures‖ CRC Press, 2002

3. Nadim Maluf," An Introduction to Micro Electro Mechanical System Design", Artech House, 2000.

WEB RESOURCES:

1. https://www.iare.ac.in/sites/default/files/lecture_notes/AME_LECTURE_NOTES.pdf

2.https://mrcet.com/downloads/digital_notes/AE/Air%20Transportation%20Systems.pdf

Vertical-6

AERO MANAGEMENT AND SAFETY

CURRICULUM

S. No.	Course Code	Course Title	Classification		L	T	P	C
1	AE606601	Airport Management	PE	Theory	3	0	0	3
2	AE606602	Crisis Management In Aviation Industry	PE	Theory	3	0	0	3
3	AE606603	Aircraft Production and Planning Management	PE	Theory	3	0	0	3
4	AE606604	Operational Management	PE	Theory	3	0	0	3
5	AE606605	Operation and Supply Chain Analytics	PE	Theory	3	0	0	3
6	AE606606	Essentials of Entrepreneurship (NPTEL)	PE	Theory	3	0	0	3
7	AE606607	Industrial Fire Safety (NPTEL)	PE	Theory	3	0	0	3
8	AE606608	Energy Conservation And Management (NPTEL)	PE	Theory	3	0	0	3
9	AE606609	Air Lines Operation And Scheduling	PE	Theory	3	0	0	3

AE606601 AIRPORT MANAGEMENT					
Course Category: Vertical 6	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To impart knowledge in the fundamentals of planning and design of aircraft structures
- To make students aware of design of runway and taxiways at Airport.
- To make students aware of the operations at Airport

UNIT 1: INTRODUCTION	**9**

History, development, policy of air transport, aircrafts, aerodromes, air transport authorities, air transport activities, air crafts and its characteristics, airport classifications as per ICAO.

UNIT 2: AIRPORT PLANNING	**9**

Regional planning-concepts and advantages, location and planning of airport as per ICAO and F.A.A. recommendations, airport Elements -airfield, terminal area, obstructions, approach zone, zoning laws, airport capacity, airport size and site selection, estimation of future air traffic, development of new airport, requirements of an ideal airport layout..

UNIT 3: RUN WAY DESIGN	**9**

Wind rose and orientation of runway, wind coverage and crosswind component, factors affecting runway length, basic runway length, and corrections to runway length, runway geometrics and runway patterns (configurations).Runway marking, threshold limits cross section of runway.

UNIT 4: TAXIWAY DESIGN	**9**

Controlling factors, taxiway geometric elements, layout, exit taxiway, location and geometrics, holding apron, turnaround facility. Aprons -locations, size, gate positions, aircraft parking configurations and parking systems, hanger-site selection, planning and design considerations, Fuel storage area, blast pads . wind direction indicator.

UNIT 5: AIR TRAFFIC CONTROL AND VISUAL AIDS	**9**

Air traffic control objectives, control system, control network-visual aids-landing information system, airport markings and lighting

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand the fundamentals of planning and design of Airport structures.

CO2: Analyse the concepts of airport planning.

CO3: Design the path of runway and taxiways at Airport.

CO4: To make students aware of the operations at Airport

CO5: Familiarize with the air traffic control system, including the control network and communication protocols

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	-	-	-	2	2	2	2	2	-	2	-	3	3
CO2	2	2	-	-	2	3	2	-	2	2	2	-	-	3	2
CO3	2	2	2	-	2	2	3	2	2	2	2	2	2	2	1
CO4	2	2	-	-	2	-	-	2	2	-	-	-	2	-	1
CO5	2	2	-	-	2	-	2	2	2	1	2	1	2	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Airport Planning and Management" by Alexander T. Wells and Seth B. Young Introduction to Airport Management" by George Standife.

2. A Managing Airports: An International Perspective" by Anne Graham and Peter Morrell

3. H. Schlichting, "Boundary Layer Theory", McGraw-Hill, New York, 1979.

REFERENCE BOOKS:

1. "Airport Operations" by Norman Ashford, Pierre Coutu, and John R. Beasley

2. Strategic Airport Planning" by Andrew R. Goetz and Jean-Paul Rodrigue

3. "Airports: Their Development and Operation" by Robert W. Poole Jr.

WEB RESOURCES:

1. Airport Cooperative Research Program: https://www.nap.edu/organization/ACRP)

AE606602 - CRISIS MANAGEMENT IN AVIATION INDUSTRY

Course Category: Vertical 6	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To understand the case studies of various causes, characteristics of crisis.
- To understand the management techniques already in vogue and apply them to the solutions of crisis problems.

UNIT 1: INTRODUCTION TO CRISIS MANAGEMENT **9**

Crisis management; Context of the crisis in the aircraft industry; Crisis management basics; Crisis stages; Establishing a crisis management team; The role of the crisis manager

UNIT 2: CRISIS MANAGEMENT IN ACTION **9**

Putting crisis management into action; Psychology of crisis management decisions; Emergency response scenarios; Contingency plans; Damage control; A crisis management checklist

UNIT 3: AIRLINE CRISIS MANAGEMENT **9**

Context of the crisis - The airline industry; Organizational crisis and communication; Causes, Crisis

typologies; Coomb's typology; Characteristics of the crises; Consequences; Modeling crises; Crisis communication; Strategic communication.

UNIT 4: CRASH MANAGEMENT	**9**

Pre-crisis - Existing in pre-crisis phase, preparing for the worst: Contingency planning; Crisis-stage Disaster strike; Confronting the crisis; Post-crisis The National Transportation Board, Director General of Civil Aviation

UNIT 5: CASE STUDIES	**9**

Northwest airlines flight 255; American airlines flight 191; Delta airlines flight 191; Trans world airlines flight 800; Pan American World Airways flight 103; US Air flight 427; Value jet flight 592.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understanding of crisis in aviation industry.

CO2: Develop the action plan during the emergency scenario

CO3: Analyze the airline crisis management and to make solution.

CO4: In the case of an aircraft crash, be able to demonstrate understanding of pre-crisis preparation, effective reaction during a disaster, and post-crisis management.

CO5: Apply critical thinking skills to case studies of significant incidents in the aviation sector to analyse and draw lessons for upcoming crisis management scenarios.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	-	-	-	-	-	-	2	2	2	-	-	-	-
CO2	2	2	-	-	-	-	-	-	2	2	2	-	-	-	-
CO3	2	2	2	-	-	-	-	-	2	2	2	-	-	1	1
CO4	2	2	2	-	-	-	-	-	2	2	2	-	2	-	1
CO5	2	2	3	-	-	-	-	-	2	2	2	-	2	1	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Crisis Management in the Aviation Industry" by Paul O'Sullivan and Gary L. Frazier

2. "Aviation Crisis Management: The Quest for Excellence" by Alan J. Stolzer, Carl D. Halford, and John J. Goglia

REFERENCE BOOKS:

1. Aviation Security Management" by Andrew R. Thomas and Dan W. Reilly

2 Airline Operations and Management: A Management Textbook" by Gerald N. Cook and Bruce Billig

3. Strategic Airport Planning" by Andrew R. Goetz and Jean-Paul Rodrigue

WEB RESOURCES:
1. International Air Transport Association (IATA) Crisis Response Resources : https://www.iata.org/en/programs/safety/crisis-response/)

AE606603 AIRCRAFT PRODUCTION AND PLANNING MANAGEMENT						
Course Category: Vertical 6	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To understand the various components and functions of production planning and control such as product planning, product scheduling and inventory
- To understand the requirements for tools and equipments for planning
- To obtain knowledge in the areas of planning and control.

UNIT 1: INTRODUCTION	**9**
Factors affecting planning-Forecasting information necessary for pre-planning-sources of information-Methods of forecasting-aircraft components requiring overhaul-repair modifications-premature-failures-project planning-estimates of plant, machinery, buildings, manpower, materials, spare parts, time, and cost estimates	
UNIT 2: MATERIALS, MACHINES AND PROCESSES	**9**
Production engineering knowledge necessary for Planning, machine tools and processes.-Materials including aircraft materials and their processing-Spare parts required for overhaul and maintenance-Ground handling equipment-testing of components and aircraft overhaul-standards for acceptance after overhaul	
UNIT 3: EQUIPMENT AND TOOLS	**9**
Pre-planning required for provision of special tools, jigs, fixtures and test equipment required for overhaul and maintenance-types and description of major test equipment	
UNIT 4: PRODUCTION PLANNING	**9**
Production planning function of routing, estimating and scheduling – LOB - CPM and PERT. Queuing theory, sequencing in jobs, shop scheduling, assembly line balancing-charts and graphs	
UNIT 5: PRODUCTION CONTROL	**9**
Production control functions of dispatching, progressing and evaluation- Activities of progressing-shop procedures - maintenance of critical data statistics of evaluation control charts	
TOTAL: 45 PERIODS	

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand the concept of planning and forecasting.

CO2: Gain ideas in the areas of aircraft materials and processes.

CO3: Understand the production planning and control

CO4: Understand queuing theory, job sequencing, shop scheduling, and assembly line balancing

CO5: Understand the functions of production control, including dispatching, progressing, and evaluation

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	3	2	-	-	-	-	-	-	-	-	2	-	-
CO2	3	3	3	2	-	-	-	-	-	-	-	2	-	-	
CO3	3	2	1	2	-	-	-	-	1	1	1	1	2	2	1
CO4	3	2	1	2	1	1	1	-	-	-	-	1	2	-	1
CO5	3	3	3	2	1	1	1	-	1	1	1	1	2	2	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Thomas. L. "Production planning and control" Mc Graw Hill, Second edition 1991.

2. Jain. K. C. and Aggarwal. L. N. "Production planning and control and Industrial Management.

REFERENCE BOOKS:

1. Buffa. E. S. and Sarin. R. K. "Modern production / operations management "8th ed, John Willey and sons, 2000.

2. . MacNiece. E. H. "Production forecasting, planning and control", John Willey, Third edition1986.

3. Mages. J. F. "Production planning and Inventory control", McGraw Hill, 1990

WEB RESOURCES:

1. Production Planning: https://www.lean.org/)

AE606604 - OPERATIONAL MANAGEMENT

Course Category: Vertical 6	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To provide a broad introduction to the field of operational management.
- To provide knowledge in tools and techniques for managing the transformation process that can lead to competitive advantage.

UNIT 1: INTRODUCTION TO OPERATIONS MANAGEMENT **9**

Operations Management – Nature, Importance, historical development, transformation processes, differences between services and goods, a system perspective, functions, challenges, current priorities, recent trends; Operations Strategy – Strategic fit , framework; Supply Chain Management

UNIT 2: FORECASTING, CAPACITY AND FACILITY DESIGN	9

Demand Forecasting – Need, Types, Objectives and Steps. Overview of Qualitative and Quantitative methods. Capacity Planning – Long range, Types, Developing capacity alternatives. Overview of sales and operations planning. Overview of MRP, MRP II and ERP. Facility Location – Theories, Steps in Selection, Location Models. Facility Layout – Principles, Types, Planning tools and techniques..

UNIT 3: DESIGN OF PRODUCT, PROCESS AND WORK SYSTEMS	9

Product Design – Influencing factors, Approaches, Legal, Ethical and Environmental issues. Process – Planning, Selection, Strategy, Major Decisions. Work Study – Objectives, Procedure. Method Study and Motion Study. Work Measurement and Productivity – Measuring Productivity and Methods to improve productivity..

UNIT 4: MATERIALS MANAGEMENT	9

Materials Management – Objectives, Planning, Budgeting and Control. Purchasing – Objectives, Functions, Policies, Vendor rating and Value Analysis. Stores Management – Nature, Layout, Classification and Coding. Inventory – Objectives, Costs and control techniques. Overview of JIT

UNIT 5: SCHEDULING AND PROJECT MANAGEMENT	9

Project Management – Scheduling Techniques, PERT, CPM; Scheduling - work centers – nature, importance; Priority rules and techniques, shopfloor control; Flow shop scheduling – Johnson's Algorithm – Gantt charts; personnel scheduling in services.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understanding of the strategic and operational decisions in managing manufacturing and service organizations

CO2: Understanding of tools and techniques involved in forecasting methods.

CO3: Design the product and various methods to improve the productivity.

CO4: Understanding of scheduling techniques

CO5: Apply skills in ensuring the good quality of grid that is essential to get reasonably accurate solutions for complex aerospace engineering problems

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	2	-	-	-	-	-	2	2	2	2	2	-	-
CO2	2	2	-	-	2	-	-	-	-	-	-	2	2	2	-
CO3	-	2	2	2		-	-	-	2	2	2	-	2	2	-
CO4	2	2	-	2	2	-	-	-	2	-	-	-	2	-	2
CO5	2	2	1	2	3	-	-	-	2	-	-	-	3	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Richard B. Chase, Ravi Shankar, F. Robert Jacobs, Nicholas J. Aquilano, Operations and Supply

Management, Tata McGraw Hill, 12th Edition, 2010..
2. Norman Gaither and Gregory Frazier, Operations Management, South Western Cengage Learning, 2002
REFERENCE BOOKS:
1. William J Stevenson, Operations Management, Tata McGraw Hill, 9th Edition, 2009.
2. Russel and Taylor, Operations Management, Wiley, Fifth Edition, 2006.
3. Kanishka Bedi, Production and Operations Management, Oxford University Press, 2004..
4. Chary S. N, Production and Operations Management, Tata McGraw Hill, Third Edition, 2008.
5. Aswathappa K and Shridhara Bhat K, Production and Operations Management, Himalaya Publishing House, Revised Second Edition, 2008
WEB RESOURCES:
1. Introduction to Operations Management: https://hbr.org/topic/operations
2. Scheduling and Project Management: https://www.poms.org/)

AE606605 OPERATION AND SUPPLY CHAIN ANALYTICS						
Course Category: Vertical 6	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						
• To treat the subject in depth by emphasizing on the advanced quantitative models and methods in operations and supply chain management • Learn various analytical techniques and tools used in operations and supply chain management • Apply quantitative methods and data analytics to optimize operational and supply chain decisions.						
UNIT 1: - INTRODUCTION						**9**
Descriptive, predictive and prescriptive analytics, Data Driven Supply Chains – Basics, transforming supply chains.						
UNIT 2: WAREHOUSING DECISIONS						**9**
P-Median Methods - Guided LP Approach, Greedy Drop Heuristics, Dynamic Location Models, Space Determination and Layout Methods						
UNIT 3 INVENTORY MANAGEMENT						**9**
Dynamic Lot sizing Methods, Multi-Echelon Inventory models, Aggregate Inventory system and LIMIT, Risk Analysis in Supply Chain, Risk pooling strategies..						
UNIT 4: TRANSPORTATION NETWORK MODELS						**9**
Minimal Spanning Tree, Shortest Path Algorithms, Maximal Flow Problems, Transportation Problems, Set covering and Set Partitioning Problems, Travelling Salesman Problem, Scheduling Algorithms.						
						9

UNIT 5: MCDM MODELS

Minimal Spanning Tree, Shortest Path Algorithms, Maximal Flow Problems, Transportation Problems, Set covering and Set Partitioning Problems, Travelling Salesman Problem, Scheduling Algorithms.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. To enable quantitative solutions in business decision making under conditions of certainty, risk and uncertainty.

CO2. Discuss the characteristics and the selection of traction motor.

CO3. Comprehend the vehicle-to-vehicle and autonomous technology.

CO4. Explain the networking of various modules in automotive systems, communication protocols and diagnostics of the sub systems.

CO5. Be familiar with on-board diagnostics systems.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO2	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO3	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO4	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO5	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Nada R. Sanders, Big data driven supply chain management: A framework for implementing analytics and turning information into intelligence, Pearson Education, 2014.

2. Michael Watson, Sara Lewis, Peter Cacioppi, Jay Jayaraman, Supply Chain Network Design: Applying Optimization and Analytics to the Global Supply Chain, Pearson Education, 2013.

REFERENCE BOOKS:

1. Muthu Mathirajan, Chandrasekharan Rajendran, Sowmyanarayanan Sadagopan, Arunachalam Ravindran, Parasuram Balasubramanian, Analytics in Operations/Supply Chain Management , I.K. International Publishing House Pvt. Ltd., 2016

2. Gerhard J. Plenert, Supply Chain Optimization through Segmentation and Analytics, CRC Press, Taylor & Francis Group, 2014.

WEB RESOURCES:

1. supply chain analytics: vehicles:https://nptel.ac.in/courses/108106170

AE606606 - Essentials of Entrepreneurship (NPTEL)						
Course Category: Vertical 6	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- Understand the fundamentals of entrepreneurship.
- To impart the entrepreneurial skills and traits essential to become successful entrepreneurs.
- To understand the Production and Operations Management Control for business owners
- Write business plans; Comprehend emerging issues of entrepreneurship.

UNIT 1: INTRODUCTION TO ENTREPRENEURSHIP	**9**
Entrepreneurship- Definition, Need, Scope - Entrepreneurial Skill & Traits - Entrepreneur vs. Intrapreneur; Classification of entrepreneurs, Types of entrepreneurs -Factors affecting entrepreneurial development – Achievement Motivation – Contributions of Entreprenrship to Economic Development	
UNIT 2: BUSINESS OWNERSHIP & ENVRIONMENT	**9**
Types of Business Ownership – Buiness Envrionemental Factors – Political-Economic-Sociological-Technological-Environmental-Legal aspects – Human Reosurces Mobilisation-Basics of Managing Finance-Esentials of Marketing Management - Production and Operations Planning – Systems Management and Administration.	
UNIT 3: FUNDAMENTALS OF TECHNOPRENEURSHIP	**9**
Introduction to Technopreneurship - Definition, Need, Scope- Emerging Concepts- Principles - Characterisitcis of a technopreneur - Impacts of Technopreneurship on Society – Economy- Job Opportuinites in Technopreneurship - Recent trends.	
UNIT 4: APPLICATIONS OF TECHNOPRENEURSHIP	**9**
Technology Entrepreneurship - Local, National and Global practices - Intrapreneurship and Technology interactions, Networking of entrepreneurial activities – Launching - Managing , Technology based Product / Service entrepreneurship -– Success Stories of Technopreneurs - Case Studies	
UNIT 5: EMERGING TRENDS IN ENTREPRENERUSHIP	**9**
Effective Business Management Strategies For Franchising- Sub-Contracting- Leasing- Technopreneurs – Agripreneurs - Netpreneurs- Portfolio entrepreneruship - NGO Entrepreneurship Recent Entrperneruial Develoments - Local – National – Global perspectives.	
	TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Learn the basics of Entrepreneurship
CO2. Understand the business ownership patterns and evnironment
CO3. Understand the Job opportunites in Industries relating to Technopreneurship
CO4. Learn about applications of tehnopreneurship and successful technopreneurs.
CO5. Acquaint with the recent and emerging trends in entrepreneruship.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	2	2	-	-	-	2	-	3	2	2	2	1
CO2	2	2	2	2	2	-	-	-	2	-	-	2	2	2	1
CO3	3	2	2	2	-	-	-	-	2	-	1	2	-	2	1
CO4	3	2	2	2	2	-	-	-	2	-	2	2	2	-	1
CO5	2	2	2	2	2	-	-	-	2	-	2	2	2	2	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Entrepreneurship: Theory, Process, and Practice" by Donald F. Kuratko (2020)

2. Essentials of Entrepreneurship and Small Business Management" by Thomas W. Zimmerer, Norman M. Scarborough, and Jeffrey R. Cornwall (2021)

REFERENCE BOOKS:

1. "Entrepreneurship: Successfully Launching New Ventures" by Bruce R. Barringer and R. Duane Ireland (2019).

2 Technopreneurship: Innovation and Entrepreneurship in High Technology Industries" by Thomas N. Duening, Robert A. Hisrich, and Michael A. Lechter (2018).

WEB RESOURCES:

1. Essentials of Entrepreneurship : ://nptel.ac.in/courses/108106134

AE606607 - Industrial Fire Safety (NPTEL)

Course Category: Vertical 6	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To enable the students to acquire knowledge of Fire and Safety Studies.
- To learn about the effect of fire on materials used for construction, the method of test for non- combustibility & fire resistance
- To learn about fire area, fire stopped areas and different types of fire-resistant doors
- To learn about the method of fire protection of structural members and their repair due to fire damage.
- To develop safety professionals for both technical and management through systematic and quality-based study programmers

UNIT 1: INHERENT SAFETY CONCEPTS **9**

Compartment fire-factors controlling fire severity, ventilation controlled and fuel controlled fires; Spread of fire in rooms, within building and between buildings. Effect of temperature on the properties of structural materials- concrete, steel, masonry and wood; Behavior of non-structural materials on fire- plastics, glass, textile fibres and other house hold materials

UNIT 2: PLANT LOCATIONS **9**

Compartment temperature-time response at pre-flashover and post flashover periods; Equivalence of fire severity of compartment fire and furnace fire; Fire resistance test on structural elements- standard heating condition, Indian standard test method, performance criteria

UNIT 3: WORKING CONDITIONS **9**

Fire separation between building- principle of calculation of safe distance. Design principles of fire resistant walls and ceilings; Fire resistant screens- solid screens and water curtains; Local barriers; Fire stopped areas- in roof, in fire areas and in connecting structures; Fire doors- Low combustible, Non-combustible and Spark-proof doors; method of suspension of fire doors; Air-tight sealing of doors.

UNIT 4: FIRE SEVERITY AND REPAIR TECHNIQUES **9**

Fabricated fire proof boards-calcium silicate, Gypsum, Vermiculite, and Perlite boards; Fire protection of structural elements - Wooden, Steel and RCC.. Reparability of fire damaged structures- Assessment of damage to concrete, steel, masonry and timber structures, Repair techniques- repair methods to reinforced concrete Columns, beams and slabs, Repair to steel structural members, Repair to masonry structures

UNIT 5: WORKING AT HEIGHTS **9**

Safe Access - Requirement for Safe Work Platforms- Stairways - Gangways and Ramps-Fall Prevention & Fall Protection - Safety Belts - Safety nets - Fall Arrestors- Working on Fragile Roofs - Work Permit Systems-Accident Case Studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand the effect of fire on materials used for construction.

CO2: Understand the method of test for non-combustibility and fire resistance; and will be able to select different structural elements and their dimensions for a particular fire resistance rating of a building

CO3 To understand the design concept of fire walls, fire screens, local barriers and fire doors and able to select them appropriately to prevent fire spread.

CO4: To decide the method of fire protection to RCC, steel, and wooden structural elements and their repair methods if damaged due to fire.

CO5: Describe the safety techniques and improve the analytical and intelligence to take the right decision at right time.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	-	1	-	-	1	-	-	-	-	-	-	-	-	-
CO2	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-
CO3	1	-	2	-	-	-	3	-	-	1	-	-	-	-	-
CO4	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-
CO5	2	-	1	-	-	1	1	1	-	1	-	1	-	-	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:
1. Roytman, M. Y,"Principles of fire safety standards for building construction". Amerind Publishing Co. Pvt. Ltd., New Delhi,1975
2. John A. Purkiss,"Fire safety engineering design of structures" (2nd edn.), Butterworth Heinemann, Oxford, UK,2009.
REFERENCE BOOKS:
1. Smith, E.E. and Harmathy, T.Z. (Editors),"Design of buildings for fire safety". ASTM Special Publication 685, American Society for Testing and Materials, Boston, U.S.A,1979.
2. Butcher, E. G. and Parnell, A. C, "Designing of fire safety". JohnWiley and Sons Ltd., New York, U.S.A.1983
WEB RESOURCES:
1. Industrial Fire Safety: https://nptel.ac.in/courses/101104095

AE606608 Energy Conservation And Management (NPTEL)						
Course Category: Vertical 8	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- Evaluate and analyse the energy data of industries
- Analyse the energy accounting and balancing
- Evaluate and conduct energy audit and suggest methodologies for energy savings and utilise the available resources in optimal ways

UNIT 1: INTRODUCTION	**9**
Energy - Power – Past & Present scenario of World; National Energy consumption Data – Environmental aspects associated with energy utilization – Energy Auditing: Need, Types, Methodology and Barriers. Role of Energy Managers. Instruments for energy auditing.	
UNIT 2: ELECTRICAL SYSTEMS	**9**
Components of EB billing – HT and LT supply, Transformers, Cable Sizing, Concept of Capacitors, Power Factor Improvement, Harmonics, Electric Motors - Motor Efficiency Computation, Energy Efficient Motors, Illumination – Lux, Lumens, Types of lighting, Efficacy, LED Lighting and scope of Encon in Illumination..	
UNIT 3: THERMAL SYSTEMS	**9**
Stoichiometry, Boilers, Furnaces and Thermic Fluid Heaters – Efficiency computation and encon measures. Steam: Distribution &U sage: Steam Traps, Condensate Recovery, Flash Steam Utilization, Insulators &	

Refractories.

UNIT 4: ENERGY CONSERVATION IN MAJOR UTILITIES **9**

Pumps, Fans, Blowers, Compressed Air Systems, Refrigeration and Air Conditioning Systems –Cooling Towers – D.G. sets.

UNIT 5: APPLICATIONS OF MEMS **9**

Energy Economics – Discount Rate, Payback Period, Internal Rate of Return, Net Present Value, Life Cycle Costing –ESCO concept

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Remember the knowledge for Basic combustion and furnace design and selection of thermal and mechanical energy equipment.

CO2 Study the Importance of Stoichiometry relations, Theoretical air required for complete combustion.

CO3: Skills on combustion thermodynamics and kinetics..

CO4 Apply calculation and design tube still heaters.

CO5: Studied different heat treatment furnace.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO2	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-
CO3	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-
CO4	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-
CO5	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Energy Manager Training Manual (4 Volumes) available at www.energymanagertraining.com. a website administered by Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power, Government of India, 2004.

REFERENCE BOOKS:

1. Witte. L.C., P.S. Schmidt, D.R. Brown, "Industrial Energy Management and Utilisation" Hemisphere Publ, Washington, 1988

2. Callaghn, P.W. "Design and Management for Energy Conservation", Pergamon Press, Oxford, 1981

3. Turner. W.C., "Energy Management Hand book", Wiley, New York, 1982

WEB RESOURCES:

1. Energy Conservation And Management: https://nptel.ac.in/courses/117105045

AE606609 AIR LINES OPERATION AND SCHEDULING						
Course Category: Vertical 6	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

- To understand the organization details in air-transportation.
- To study the principles of airline scheduling.
- To understand the airline maintenance schedule and monitoring.

UNIT 1: INTRODUCTION	**9**

Development of air transportation, comparison with other modes of transport – Role of IATA, ICAO – The general aviation industry airline – Factors affecting general aviation, use of aircraft, airport: airline management and organisation – levels of management, functions of management, Principles of organisation planning the organisation – chart, staff departments & line departments.

UNIT 2: AIRLINE ECONOMICS AND FLEET PLANNING:	**9**

Forecasting – Fleet size, Fleet planning, the aircraft selection process, operating cost, passenger capacity, load factor etc. – Passenger fare and tariffs – Influence of geographical, economic & political factors on routes and route selection.

The aircraft selection process – Fleet commonality, factors affecting choice of fleet, route selection and Capitol acquisition – Valuation & Depreciation – Budgeting, Cost planning – Aircrew evaluation – Route analysis – Aircraft evaluation

UNIT 3: PRINCIPLES OF AIRLINES SCHEDULING	**9**

Equipment maintenance, Flight operations and crew scheduling, Ground operations and facility limitations, equipments and types of schedule – hub & spoke scheduling, advantages / disadvantages & preparing flight plans – Aircraft scheduling in line with aircraft maintenance practices.

UNIT 4: AIRCRAFT RELIABILITY	**9**

Aircraft reliability – The maintenance schedule & its determinations – Condition monitoring maintenance – Extended range operations (EROPS) & ETOPS – Ageing aircraft maintenance production

UNIT 5: TECHNOLOGY IN AIRCRAFT MAINTENANCE	**9**

Airlines scheduling (with reference to engineering) – Product support and spares – Maintenance sharing – Equipments and tools for aircraft maintenance – Aircraft weight control – Budgetary control.On board maintenance systems – Engine monitoring – Turbine engine oil maintenance – Turbine engine vibration monitoring in aircraft – Life usage monitoring – Current capabilities of NDT – Helicopter maintenance – Future of aircraft maintenance.

Total: 45 periods

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand the concepts of organization details in air transportation.

CO2: Acquire knowledge in airline Economics and fleet planning

CO3: Understand the aircraft reliability.

CO4: understand various problems faced by airline

CO5: Understand the various technologies related to aircraft maintenance

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	3	-	-	-	-	-	-	2	-	2	2	-	-
CO2	2	2	-	-	-	-	-	-	-	-	-	2	1	-	-
CO3	-	2	2	2	-	-	-	-	-	2	-	-	1	1	2
CO4	2	-	-	2	2	-	-	-	2	2	2	-	1	1	-
CO5	2	2	2	2	2	-	-	-	2	2	2	-	1	-	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Fedric J.H., "Airport Management", Anybook Ltd Edition II 2000

2. Alexander T Wells, "Air Transportation", Wadsworth Publishing Company, California, 1993

REFERENCE BOOKS:

1. Gene Kropf, "Airline Procedures" McGraw-Hill; First Edition edition 1949..

2. Philip Locklin D, "Economics of Transportation". Irwin (Richard D.) Inc,U.S. 7th Revised edition 1974

3. Indian Aircraft manual" – DGCA Pub Volume I,II ,III revised edition 2003

WEB RESOURCES:

1. Air lines operation: https://nptel.ac.in/courses/101104071

Vertical-7

DIVERSIFIED COURSES
GROUP 1

CURRICULUM

S. No.	Course Code	Course Title	Classification		L	T	P	C
1	AE606701	Design of Gas Turbine Engine Components	PE	Theory	3	0	0	3
2	AE606702	Vibration and aero elasticity (NPTEL)	PE	Theory	3	0	0	3
3	AE606703	Manufacturing process	PE	Theory	3	0	0	3
4	AE606704	Turbo machines (NPTEL)	PE	Theory	3	0	0	3
5	AE606705	Helicopter theory (NPTEL)	PE	Theory	3	0	0	3
6	AE606706	Design of Non air breathing engine	PE	Theory	3	0	0	3
7	MA606707	Mechatronics (NPTEL)	PE	Theory	3	0	0	3
8	AE606304	Project management	PE	Theory	3	0	0	3
9	AE606709	Computer aided design and analysis	PE	Theory	3	0	0	3

AE606701 DESIGN OF GAS TURBINE ENGINE COMPONENTS						
Course Category: Vertical 7	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To introduce basic design concepts of jet engine and estimation of required thrust to students.
- To make students familiarize with the design parameter and off design calculations.
- To give the students adequate exposure to design procedure to the rotating components of engine such as compressor and turbine along with staging.
- To make the students learn the aspects of combustion processes, flame stabilization issue, igniters design and NOx controls.
- To make students familiarize with the concept of design inlet and nozzle for various on - off design conditions

UNIT 1: GAS TURBINE ENGINE DESIGN FUNDAMENTALS	**9**

Design Process- compressible flow relationship; Constraint Analysis - Concept-Design tools- preliminary estimates; Mission analysis - Aircraft weight and fuel consumption data-Example problems on Constrain analysis, Mission analysis.

UNIT 2 : ON DESIGN AND OFF-DESING PARAMETRIC ANALYSIS	**9**

Total and static properties-corrected mass flow rate-Engine Cycle Design- One-Dimensional Through flow Area-Flow path force on components- aircraft constraint analysis, aircraft mission analysis, engine parametric (design point) analysis, engine performance (off-design) analysis, engine installation drag and sizing.

UNIT 3: DESIGN OF ROTATING COMPONENTS	**9**

Fan and Compressor Aerodynamics-Diffusion factor-Aerofoil geometry-Flow path dimension- Radial variation-Turbine Aerodynamics- Constant axial velocity-adiabatic-selected Mach number-Mean line stage Design-stage pressure ratio-Airfoil geometry-radial variation-turbine cooling-range of turbine parameters-Engine life-Design Example –for fan-compressor-turbine.

UNIT 4 : COMBUSTION CHAMBER DESIGN	**9**

Design: Combustion system components- Combustion- Chemical reactor theory. Combustor Stabilitymap-Stirringandmixing-Totalpressureloss-Fuels-Ignition-CombustionSystemsofMain Burner Design: Air partitioning- Main burner component Design: Diffuser-types of burner-inner and outer casing design-Fuel nozzle-Dome and liner-Primary zone- swirler-Secondary holes- Dilution holes-Transition duct-Design of Afterburners-Design parameters-Diffuser-Fuel injection- Ignition-Flame stabilization – Flame spread and after burner length – Examples design calculation.

UNIT 5 : INLET AND NOZZLE DESIGN	**9**

Inlets and Exhaust Nozzles Design: Elements of a Successful Inlet-Engine Integration Program- Definition of Subsonic Inlet-Engine Operational Requirements- Definition of Supersonic Inlet- Engine Operational

Requirements- Engine Impact on Inlet Design- Inlet Impact on Engine Design-Validation of Inlet-Engine System-Exhaust nozzle design-Nozzle types and their design

-Jet control methods for reduction of infrared signature.

TOTAL: 45 PERIODS

COURSE OUTCOMES: Upon completion of this course, Students will be able to

CO1: Do preliminary weight and fuel estimation for an aircraft mission..

CO2: Identify variation in parametric analysis of ON and OFF design calculations.

CO3: Explain the principle design of compressor and turbine and selection of suitable materials.

CO4: Estimate the total pressure losses and able to predict ignition delay

CO5: Determine the basic design factors affects ON and OFF design operation of inlets and nozzle on engine performance.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	3	2	1	-	-	-	1	1	1	1	-	-	-
CO2	3	3	3	2	2	-	-	-	1	1	1	1	-	-	-
CO3	3	3	2	2	2	1	2	-	1	1	1	1	-	-	-
CO4	3	3	3	2	2	1	2	1	1	1	1	1	-	-	-
CO5	3	3	3	-	2	2	2	1	1	1	1	1	1	1	-

1- low, - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Mattingly J.D., Heiser, W.H. and Pratt D.T, 'Aircraft Engine Design', 2nd Edition, AIAA Education Series, AIAA, 2002..

2. Oates G.C.,' Aircraft Propulsion Systems Technology and Design',1989, AIAA Education Series..

3. Saravanamuttoo H.I.H andRogers, G.F.C."Gas Turbine Technology", Pearson Education Canada; 6th edition, 2008..

REFERENCE BOOKS:

1.Cumpsty N., "Jet Propulsion: A Simple Guide to the Aerodynamics and ThermodynamicsDesign and Performance of Jet Engines" , Cambridge University Press; 2nd edition, 2003

2. Murthy S.N. and Curran E.T.,' High-Speed Flight Propulsion Systems', Volume 137, Progress in Astronautics and Aeronautics, AIAA,1991..

3. Rathakrishnan E, 'Applied Gas Dynamics, John Wiley & Sons (Asia) Pvt Ltd, 2010.

4. Treage I.E, Aircraft Gas Turbine Engine Technology, 3rd edition, Glencoe McGraw-Hill, Inc. 1995

AE606702 VIBRATION AND AERO ELASTICITY(NPTEL)						
Course Category: Vertical 7	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

- To study the effect of time dependent forces on mechanical systems and to get the natural characteristics of system of single degree of freedom system
- To study the solving methods of multi degree of freedom systems.
- To introduce the approximates method to solve vibration problems.
- To make the student to understand the solving techniques of vibration of continuous system
- To study the aeroelastic effects of aircraft wings.

UNIT 1: SINGLE DEGREE OFFREEDOMSYSTEMS	**9**

Introduction to simple harmonic motion, D'Alembert's principle, free vibrations – damped vibrations - forced vibrations, with and without damping – support excitation – transmissibility - vibration measuring instruments.

UNIT 2: MULTI DEGREE OFFREEDOMSYSTEMS	**9**

Two degrees of freedom systems - static and dynamic couplings - vibration absorber- Multi degree of freedom systems - principal co-ordinates - principal modes and orthogonal conditions - Eigen value problems - Hamilton's principle - Lagrangean equations and application.

UNIT 3: CONTINUOUS SYSTEMS	**9**

Vibration of elastic bodies - Vibration of strings – longitudinal, lateral and torsional vibrations

UNIT 4: APPROXIMATE METHODS	**9**

Approximate methods - Rayleigh's method - Dunkerley's method – Rayleigh-Ritz method- Holzer method - Matrix iteration method.

UNIT 5: ELEMENTS OFAEROELASTICITY	**9**

Vibration due to coupling of bending and torsion - aeroelastic problems - Collars triangle - wing divergence - aileron control reversal – flutter – buffeting. – elements of servo elasticity

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Solve single and multi-degree vibrating systems

CO2: Distinguish types of vibrations according to dampness and particle motion.

CO3: Solve the different numerical methods to solve continuous system

CO4: Solve approximate methods to find natural frequency of a system

CO5: Examine Collars Triangle and Aero Elastic Problems

CO6**:** Examine the effect of Aileron reversal, flutter and wing divergence

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	1	1	1	-	-	1	-	-	1	-	2	2	1
CO2	3	2	1	1	2	-	-	-	1	1	1	1	2	2	-
CO3	3	2	1	1	2	-	-	1	1	1	1	1	3	2	1
CO4	3	2	1	-	2	-	-	-	1	1	1	1	3	2	1
C05	3	2	1	-	2	-	-	1	1	1	1	1	3	2	1
CO6	3	2	2	1	2	1	1	2	1	1	1	2	3	3	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Grover. G.K., "Mechanical Vibrations", 7th Edition, Nem Chand Brothers, Roorkee, India,2003.

2. Leonard Meirovitch, "Elements of Vibration Analysis". McGraw Hill InternationalEdition,2007

3. Thomson W T, 'Theory of Vibration with Application' - CBS Publishers,1990.

REFERENCE BOOKS:

1. Bisplinghoff R.L., Ashely H and Hogman R.L., "Aeroelasticity", Addision Wesley Publication, New Tork,1983.

2. en Hartog, "Mechanical Vibrations" Crastre Press,2008..

3. TSE. F.S., Morse, I.F., Hinkle, R.T., "Mechanical Vibrations" – Prentice Hall, New York,1984

4. William W Seto, "Mechanical Vibrations" – McGraw Hill, SchaumSeries.

5. William Weaver, Stephen P. Timoshenko, Donovan H. Yound, Donovan H. Young. 'Vibration Problems in Engineering' – John Wiley and Sons, New York,2001

WEB RESOURCES:

1. vibration and aero elasticity: https://nptel.ac.in/courses/1034569140

AE606703 MANUFACTURING PROCESS

Course Category: Vertical 7	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To illustrate the working principles of various metal casting processes.
- To learn and apply the working principles of various metal joining processes.

- To analyse the working principles of bulk deformation of metals.
- To learn the working principles of sheet metal forming process.
- To study and practice the working principles of plastics molding

UNIT 1: METAL CASTING PROCESSES	**9**

Sand Casting – Sand Mould – Type of patterns - Pattern Materials – Pattern allowances – Molding sand Properties and testing – Cores –Types and applications – Molding machines – Types and applications– Melting furnaces – Principle of special casting processes - Shell,investment – Ceramic mould – Pressure diecasting–lowpressure,gravity-Tiltpouring,highpressurediecasting-CentrifugalCasting–CO2casting –- Defects in Sand casting process-remedies.

UNIT 2: METAL JOINING PROCESSES	**9**

Fusion welding processes – Oxy fuel welding – Filler and Flux materials-–Arc welding, Electrodes, Coat-ingandspecifications–GasTungstenarcwelding–Gasmetalarcwelding-Submergedarcwelding– Electro slag welding– Plasma arc welding — Resistance welding Processes -Electron beam welding – Laser beam Welding Friction welding – Friction stir welding – Diffusion welding – Thermit Welding, Weld defects – inspection &remedies – Brazing - soldering – Adhesive bonding

UNIT 3: BULK DEFORMATION PROCESSES	**9**

Hot working and cold working of metals – Forging processes – Open, impression and closed die forging –cold forging- Characteristics of the processes – Typical forging operations – rolling of metals – Types of Rolling – Flat strip rolling – shape rolling operations – Defects in rolled parts – Principle of rod and wire drawing – Tube drawing – Principles of Extrusion – Types – Hot and Cold extrusion. Introduction to shaping operations

UNIT 4: SHEET METAL PROCESSES	**9**

Sheet metal characteristics – Typical shearing, bending and drawing operations – Stretch forming operations – Formability of sheet metal – Test methods –special forming processes - Working principle and applications – Hydro forming – Rubber pad forming – Metal spinning – Introduction of Explosive forming, magnetic pulse forming, peen forming, Super plastic forming – Micro forming – Incremental forming.

UNIT 5: MANUFACTURE OF PLASTIC COMPONENTS	**9**

Types and characteristics of plastics – Molding of thermoplastics & Thermosetting polymers– working principles and typical applications – injection molding – Plunger and screw machines – Compression molding, Transfer Molding – Typical industrial applications – introduction to blow molding – Rotational molding – Film blowing – Extrusion – Thermoforming – Bonding of Thermoplastics- duff moulding.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Explain the principle of different metal casting processes.

CO2: Describe the various metal joining processes.

CO3: Illustrate the different bulk deformation processes.

CO4: Illustrate the different bulk deformation processes

C05 : Apply suitable molding technique for manufacturing of plastics components.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3		2			2	3	1	1	-	-	1	3	1	2
CO2	3		2			2	3	1	1	-	-	1	3	1	2
CO3	3		2			2	2	1	1	-	-	1	3	1	2
CO4	3		2			2	2	1	1	-	-	1	3	1	2
CO5	3		2		2	2	2	1	1	-	-	1	3	1	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Kalpakjian. S, "Manufacturing Engineering and Technology", Pearson Education India,4th Edition, 2013.

2.P.N.Rao Manufacturing Technology Volume 1 Mc Grawhill Education 5th edition,2018.

REFERENCE BOOKS:

1.Roy. A. Lindberg, Processes and materials of manufacture, PHI / Pearson education, 2006.

2. Paul Degarma E, Black J.T and Ronald A. Kosher, Eligth Edition, Materials and Processes, in Manufacturing, Eight Edition, Prentice – Hall of India, 1997.

3. HajraChouldhary S.K and Hajra Choudhury. AK., Elements of workshop Technology, volume I and II, Media promoters and Publishers Private Limited, Mumbai, 1997

4. Sharma, P.C., A Text book of production Technology, S.Chand and Co. Ltd., 2004

AE606704 TURBO MACHINES (NPTEL)

Course Category: Vertical 7	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To study the energy transfer in rotor and stator parts of the turbo machines.
- To study the function of various elements of centrifugal fans and blowers
- To evaluating the working and performance of centrifugal compressor.
- To analyzing flow behavior and flow losses in axial flow compressor.
- To study the types and working of axial and radial flow turbines

UNIT 1: WORKING PRINCIPLES **9**

Classification of Turbomachines. Energy transfer between fluid and rotor - Euler equation and its interpretation. Velocity triangles. Efficiencies in Compressor and Turbine stages. Degree of reaction. Dimensionless parameters for Turbomachines.

UNIT 2: CENTRIFUGAL FANS AND BLOWERS **9**

Types – components – working. Flow analysis in impeller blades-volute and diffusers. Velocity triangles

- h-s diagram. Stage parameters in fans and blowers. Performance characteristic curves – various losses. Fan – bearings, drives and noise

UNIT 3: CENTRIFUGAL COMPRESSOR **9**

Components - blade types. Velocity triangles - h-s diagram, stage work. Slip factor and Degree of Reaction. Performance characteristics and various losses. Geometry and performance calculation

UNIT 4: AXIAL FLOW COMPRESSOR **9**

Construction details. Work done factor. Velocity triangles -h-s diagram, stage work. Workdone factor. Performance characteristics, efficiency and stage losses–Stalling and Surging. Free and Forced vortex flow.

UNIT 5: AXIAL AND RADIAL FLOW TURBINES **9**

Axial flow turbines-Types–Elements-Stage velocity diagrams-h-s diagram, stage work-impulse and reaction stages. Compounding of turbines. Performance coefficients and losses. Radial flow turbines: Types–Elements-Stage velocity diagrams-h-s diagram, stage work Performance coefficients and losses)

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Explain the energy transfer in rotor and stator parts of the turbo machines.

CO2: Explain the function of various elements of centrifugal fans and blowers

CO3: Evaluate the working and performance of centrifugal compressor.

CO4: Analyze flow behavior and flow losses in axial flow compressor

CO5: Explain the types and working of axial and radial flow turbines.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	1	1	-	-	-	-	1	-	-	1	3	2	1
CO2	2	1	1	1	-	-	-	-	1	-	-	1	3	2	1
CO3	2	1	1	1	-	-	-	-	1	-	-	1	3	2	1
CO4	2	1	1	1	-	-	-	-	1	-	-	1	3	2	1
CO5	2	1	1	1	-	-	-	-	1	-	-	1	3	2	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Ganesan, V., "Gas Turbines", 3rd Edition, Tata McGrawHill, 2011.

2. Yahya, S.M., "Turbines, Compressor and Fans", 4th Edition, Tata McGraw Hill, 2011.

REFERENCE BOOKS:

1. Dixon, S.L., "Fluid Mechanics and Thermodynamics of Turbomachinery", 7th Edition, Butterworth-Heinemann, 2014.

2. Gopalakrishnan. G and Prithvi Raj. D," A Treatise on Turbomachines", Scitech Publications (India) Pvt. Ltd., 2nd Edition,2008

3. Lewis, R.I., "Turbomachinery Performance Analysis" 1st Edition, Arnold Publisher,1996

4. Saravanamutto, Rogers, Cohen, Straznicky., "Gas Turbine Theory" 6th Edition, Pearson Education Ltd,2009

5. Venkanna, B.K., "Fundamentals of Turbomachinery", PHI Learning Pvt. Ltd.,2009

WEB RESOURCES:

1. Turbo machines: https://nptel.ac.in/courses/1031073458

AE606705 HELICOPTER THEORY (NPTEL)					
Course Category: Vertical 7	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- The principals involved in helicopters
- The performance and stability aspects of Helicopter under different operating conditions.
- Understand aerodynamics of rotor blades
- Dynamic stability of helicopters
- Considerations of helicopter design

UNIT 1: INTRODUCTION **9**

Helicopter as an aircraft, Basic features, Layout, Generation of lift, Main rotor, Gearbox, tail rotor, power plant, considerations on blade, flapping and feathering, Rotor controls and various types of rotor, Blade loading, Effect of solidity, profile drag, compressibility etc., Blade area required, number of Blades, Blade form, Power losses, Rotor efficiency

UNIT 2: AERODYNAMICS OFROTOR BLADE **9**

Aerofoil characteristics in forward flight, Hovering and Vortex ring state, Blade stall, maximum lift of the helicopter calculation of Induced Power, High speed limitations; parasite drag, power loading, ground effect.

UNIT 3: POWER PLANTS ANDFLIGHTPERFORMANCE **9**

Piston engines, Gas turbines, Ramjet principle, Comparative performance, Horsepower required, Range and Endurance, Rate of Climb, Best Climbing speed, Ceiling in vertical climb, Autorotation

UNIT 4: STABILITYAND CONTROL **9**

Physicaldescriptionofeffectsofdisturbances,StickfixedLongitudinalandlateraldynamicstability, lateralstabilitycharacteristics,controlresponse.Differencesbetweenstabilityandcontrolofairplane and helicopter.

UNIT 5: ROTOR VIBRATIONS **9**

Dynamic model of the rotor, Motion of the rigid blades, flapping motion, lagging motion, fathering motion, Properties of vibrating system, phenomenon of vibration, fuselage response, vibration absorbers,

Measurement of vibration in flight. Rotor Blade Design: General considerations, Airfoil selection, Blade construction, Materials, Factors affecting weight and cost, Design conditions, Stress analysis.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Make use of Aerodynamics calculation of Rotor blade

CO2: Apply stability and control characteristics of Helicopter

CO3: Experiment with control Rotor vibration.

CO4: Apply Momentum and simple blade element theories to helicopter's rotor blades

CO5: Analyse the power requirements in forward flight and associated stability problems of helicopter

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO2	2	-	1	-	-	-	1	-	1	-	-	-	2	-	-
CO3	3	1	-	-	-	-	1	-	1	1	2	1	3	2	1
CO4	3	1	-	-	-	-	-	-	1	-	-	-	2	1	1
CO5	2	-	-	-	-	-	-	-	-	-	-	-	2	2	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. John Fay, "The Helicopter and How It Flies", Himalayan Books1995

2. Lalit Gupta, "Helicopter Engineering", Himalayan Books New Delhi1996

REFERENCE BOOKS:

1. Joseph Schafer, "Basic Helicopter Maintenance", Jeppesen1980

2. R W Prouty, Helicopter Aerodynamics, Phillips Pub Co,1993.

WEB RESOURCES:

1. Helicopter theory: http://www.nitttrc.edu.in/nptel/courses/video/1121094579/L42.html

AE606706 DESIGN OF NON AIR BREATHING ENGINE					
Course Category: Vertical 8	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To establish fundamental approach and application of jet engine components.
- To learn about the analysis of flow phenomenon and estimation of thrust developed by jet engine.
- To introduce about the application of various equations in Gas Turbine Engines.
- To learn the concepts of jet engine combustion chambers.
- To acquire knowledge on compressors and turbines

UNIT 1: PRINCIPLES OF AIRBREATHING ENGINES **9**

Operating principles of piston engines – thermal efficiency calculations – classification of piston engines - illustration of working of gas turbine engines – factors affecting thrust – methods of thrust augmentation – performance parameters of jet engines

UNIT 2: JET ENGINE INTAKES ANDEXHAUSTNOZZLES **9**

Ram effect, Internal flow and Stall in subsonic inlets – relation between minimum area ratio and eternal deceleration ratio – diffuser performance – modes of operation - supersonic inlets – starting problem on supersonic inlets – shock swallowing by area variation – real flow through nozzles and nozzle efficiency – losses in nozzles – ejector and variable area nozzles - interaction of nozzle flow with adjacent surfaces – thrust reversal.

UNIT 3: JET ENGINE COMBUSTION CHAMBERS **9**

Chemistry of combustion, Combustion equations, Combustion process, classification of combustion chambers – combustion chamber performance – effect of operating variables on performance – flame stabilization, Cooling process, Materials, Aircraft fuels, HHV, LHV, Orsat apparatus

UNIT 4: JET ENGINE COMPRESSORS **9**

Euler's turbo machinery equation, Principle operation of centrifugal compressor, Principle operation of axial flow compressor– Work done and pressure rise – velocity diagrams – degree of reaction – free vortex and constant reaction designs of axial flow compressor – performance parameters axial flow compressors– stage efficiency

UNIT 5: JET ENGINE TURBINES **9**

Principle of operation of axial flow turbines– limitations of radial flow turbines- Work done and pressure rise – Velocity diagrams – degree of reaction – constant nozzle angle designs – performance parameters of axial flow turbine– turbine blade cooling methods – stage efficiency calculations – basic blade profile design considerations – matching of compressor and turbine.

TOTAL: 45 PERIODS

COURSE OUTCOMES: On completion of the course, the student is expected

CO1. To be able to apply control volume and momentum equation to estimate the forces produced by aircraft propulsion systems.

CO2. To be able to describe the principal figures of merit for aircraft engine.

CO3. To be able to describe the principal design parameters and constraints that set the performance of gas turbine engines.

CO4. To apply ideal and actual cycle analysis to a gas turbine engine to relate thrust and fuel burn to component performance parameters.

CO5. Understanding the workings of multi stage compressor or turbine, and to be able to use velocity triangles and the Euler Turbine Equation to estimate the performance of a compressor or turbine stage.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	1	1	2	3	1	1	1	2	3	1	1	3	1	1
CO2	3	2	2	2	3	2	3	2	2	3	1	1	3	1	1
CO3	3	3	3	3	2	1	2	1	3	2	1	1	3	1	1
CO4	3	3	3	2	3	2	2	1	2	1	2	1	3	1	1
CO5	3	3	2	2	3	1	1	1	1	1	1	1	3	1	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Cohen, H. Rogers, G.F.C. and Saravanamuttoo, H.I.H. "Gas Turbine Theory", Pearson Education Canada; 6th edition,2008.

2. Mathur,M.L.andSharma,R.P.,"GasTurbine,JetandRocketPropulsion",StandardPublishers & Distributors, Delhi, 2nd edition2014.

REFERENCE BOOKS:

1. Oates, G.C., "Aero thermodynamics of Aircraft Engine Components", AIAA Education Series, New York, 1985.

WEB RESOURCES:

1. https://onlinecourses.nptel.ac.in/noc23_ae11/preview

MA606707 MECHATRONICS (NPTEL)						
Course Category: Vertical 7	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for:

- Selecting sensors to develop mechatronics systems.
- Explaining the architecture and timing diagram of microprocessor, and also interpret and develop programs.
- Designing appropriate interfacing circuits to connect I/O devices with microprocessor.
- Applying PLC as a controller in mechatronics system.
- Designing and develop the apt mechatronics system for an application

UNIT 1: INTRODUCTION AND SENSORS **9**

Introduction to Mechatronics – Systems – Need for Mechatronics – Emerging areas of Mechatronics – Classification of Mechatronics. Sensors and Transducers: Static and Dynamic Characteristics of Sensor, Potentiometers – LVDT – Capacitance Sensors – Strain Gauges – Eddy Current Sensor – Hall Effect Sensor –Temperature Sensors – Light Sensors.

UNIT 2: 8085 MICROPROCESSOR **9**

Introduction – Pin Configuration - Architecture of 8085 – Addressing Modes – Instruction set, Timing diagram of 8085.

UNIT 3: PROGRAMMABLE PERIPHERAL INTERFACE **9**

Introduction – Architecture of 8255, Keyboard Interfacing, LED display – Interfacing, ADC and DAC Interface, Temperature Control – Stepper Motor Control – Traffic Control Interface

UNIT 4: PROGRAMMABLE LOGIC CONTROLLER **9**

Introduction – Architecture – Input / Output Processing – Programming with Timers, Counters and Internal relays – Data Handling – Selection of PLC.

UNIT 5: ACTUATORS AND MECHATRONICS SYSTEM DESIGN **9**

TypesofStepperandServomotors–Construction–WorkingPrinciple–Characteristics, Stages of Mechatronics Design Process – Comparison of Traditional and Mechatronics Design Concepts with Examples – Case studies of Mechatronics Systems – Pick and Place Robot – Engine Management system – Automatic Car Park Barrier.

TOTAL: 45 PERIODS

COURSE OUTCOMES: Upon successful completion of the course, students should be able to

CO1: Select sensors to develop mechatronics systems.

CO2: Explain the architecture and timing diagram of microprocessor, and also interpret and develop programs.

CO3: Design appropriate interfacing circuits to connect I/O devices with microprocessor.

CO4: Apply PLC as a controller in mechatronics system.

CO5: Design and develop the apt mechatronics system for an application

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	1	3	-	2	-	-	-	-	-	2	3	2	3
CO2	3	2	1	3	-	2	-	-	-	-	-	2	3	2	3
CO3	3	2	1	3	-	2	-	-	-	-	-	2	3	2	3
CO4	3	2	1	3	-	2	-	-	-	-	-	2	3	2	3
CO5	3	2	1	3	-	2	-	-	-	-	-	2	3	2	3

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Bolton W., "Mechatronics", Pearson Education, 6th Edition,2015.

2.Ramesh S Gaonkar, "Microprocessor Architecture, Programming, and Applications with the 8085", Penram International Publishing Private Limited, 6th Edition,2013

REFERENCE BOOKS:

1. BradleyD.A.,DawsonD.,BuruN.C.andLoaderA.J.,"Mechatronics",ChapmanandHall, 1993.

2. Davis G. Alciatore and Michael B. Histand, "Introduction to Mechatronics and Measurement systems", McGraw Hill Education,2011.

3.Devadas Shetty and Richard A. Kolk, "Mechatronics Systems Design", Cengage Learning,2010

4.Nitaigour Premchand Mahalik, "Mechatronics Principles, Concepts and Applications", McGraw Hill Education,2015

5.Smaili. A and Mrad. F, "Mechatronics Integrated Technologies for Intelligent Machines", Oxford University Press,2007

WEB RESOURCES:

1. Mechatronics: https://nptel.ac.in/courses/101104071

AE606304 PROJECT MANAGEMENT						
Course Category: Vertical 7	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

1. To impart knowledge and gain ideas in the methods and quantitative tools used to effectively plan, organize, and control construction projects.
2. To provide efficient management methods revealed through practice and research.
3. To provide hands-on, practical project management knowledge from on-site situations and field trips.

UNIT 1: Introduction to Project	**9**

Definition of a Project, Sequence of Activities, Unique activities, Complex Activities, Connected Activities, One Goal, Specified Time, Within Budget, According to Specification. Defining a Program, Project parameters: Scope, Quality, Cost, Time, Resources; The scope triangle: Time, Cost, and Resource Availability, Project Classification.

UNIT 2: Project Management	**9**

Principles of Project Management: Defining, Planning, Executing, Controlling, Closing; Project Management Life Cycle: Phases of Project Management, Levels of Project Management; Quality Management: Continuous Quality Management Model, Process Quality Management Model; Risk Management, Risk Analysis; Relationship between Project Management and other Methodologies.

UNIT 3: Project Activities	**9**

Work Breakdown Structure, Uses of WBS, Generating the WBS: Top-Down/ Bottom-Up Approach, WBS for Small Projects, Intermediate WBS for large projects; Criteria to Test for Completeness in the WBS: Measurable Status, Bounded, Deliverable, Cost/Time Estimate, Acceptable Duration Limits, Activity Independence; Approaches to Building the WBS: various approaches, Representing WBS.

UNIT 4: Network Analysis – PERT	**9**

Introduction to Project Evaluation and Review Technique, Event, Activity, Dummy, Network rules, Graphical guidelines for network, Common partial situations in network, numbering the events, Cycles; Developing the Network, Planning for network construction, modes of network construction, steps in developing network, hierarchies; Time Estimates in PERT, Uncertainties and use of PERT, Time estimates, Frequency distribution, Mean, Variance & standard deviation, Probability distribution, Beta distribution, Expected time; Time Computations in PERT, Earliest expected time, Formulation for TE, Latest allowable occurrence time, Formulation for TL, Combined tabular computations for TE, TL; Slack, Critical Path, Probability of meeting schedule date.

UNIT 5: Network Analysis - CPM	**9**

Introduction to Critical Path Method, Procedure, Networks, Activity time estimate, Earliest event time, Latest allowable occurrence time, Combined tabular computations for TE and TL, Start & Finish times of

activity, Float, Critical activities & Critical path. Crashing of project network, Resource levelling and Resource allocation.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Interpret the basics of micro electromechanical systems including their applications and advantages

CO2: Recognize the use of materials in micro fabrication and describe the fabrication processes including surface micromachining, bulk micromachining and LIGA.

CO3: Comprehend the design concepts of micro sensors.

CO4: Analyze the key performance aspects of electromechanical transducers including actuators

CO5: Apply MEMS to various disciplines

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO2	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-
CO3	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-
CO4	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-
CO5	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Chang Liu, 'Foundations of MEMS', Pearson Education Inc., 2012.

2. Stephen D Senturia, 'Microsystem Design', Springer Publication, 2000.

3. Tai Ran Hsu, "MEMS & Micro systems Design and Manufacture" Tata McGraw Hill, New Delhi, 2002.

REFERENCE BOOKS:

1. Marc Madou, ―Fundamentals of Microfabrication‖, CRC press 1997.

2. Sergey Edward Lyshevski, ―MEMS and NEMS: Systems, Devices, and Structures‖ CRC Press, 2002

3. Nadim Maluf," An Introduction to Micro Electro Mechanical System Design", Artech House, 2000.

AE606709 - COMPUTER AIDED DESIGN AND ANALYSIS						
Course Category: Vertical 7	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

To familiarize with

1. Concepts of modelling of 2D and 3D geometrical elements.
2. Concepts of computer graphics.
3. CAD Packages and its features.
4. Indian standards on drawing practices and standard components
5. the effects of real-world conditions on a part or assembly

UNIT 1: INTRODUCTION **9**

Introduction to CAD – I/O devices – various graphics standards – coordinate systems – Geometric Modelling: Introduction – types of geometric modelling – wire frame – surface and solid modelling. Wireframe entities – types of curves and its mathematical representation - line- circle- ellipse- parabola- Cubic spline- Bezier and B-spline (Only Basic treatment). Solid modelling entities - Solid modellingtechniques-CSGandBREP-OperationsperformedinCSGandBREP-Extrude-sweep - linear and Nonlinear- revolve

UNIT 2: GRAPHIC CONCEPTS (2Dand 3D) **9**

Transformations - translation- scaling- reflection- rotation. Concatenated transformation. Inverse transformation. Hidden line removal - Z-Buffer algorithm- brief description of shading and colour renderingtechniques.Manipulationandeditingofentities-selectionmethods–dragging-clipping- trimming-stretching- offsetting- pattern- copying- deleting - regenerating- measuring. Brief description of animation-types and techniques

UNIT 3: SOFTWARE PACKAGES AND RECENT TECHNOLOGY **9**

All about popular commercial solid modelling packages — their salient features- technical comparison-modulesandToolsavailable-briefoutlineofDataexchangestandards.Briefoutlineof feature technology - classification of features- design by features- applications of features- its advantages- and limitations.

UNIT 4: FEM FUNDAMENTALS **9**

Introduction to finite element method - principle- Steps involved in FEA - nodes- element and their types-shape function-constraints, forces and nodal displacements-stiffness matrix- solution techniques. Analysis of spring element. Simple problems involving stepped bars subjected to axial loading and simple structural members for triangular element

UNIT 5: ANALYSIS **9**

Stages of FEA in a CAD environment - Pre-processor- solver and postprocessor. Pre-processing - FEAmodelling-geometrygeneration-nodegeneration-elementgeneration-boundaryconstraints-load constraints- - mesh generation and refining. Solving - performing the actual analysis. Post processing-

Typesof0/Pavailable-interpretationofresults.Demonstrationoftheaboveusingany one popular commercial package. Other types of analysis: Brief outline of kinematical analysis- manufacturability analysis and simulation.

TOTAL: 45 PERIODS

COURSE OUTCOMES: On successful completion of this course, the student will be able to

CO1: Plan and read engineering drawings

CO2: Identify engineering objects and components from drawings.

CO3: Utilize solid models created in computer.

CO4: Compare the relation between 2D drafting and 3D models

CO5: Choose the graphical models for further engineering applications

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	2	2	2	-	-	-	-	-		-	2	1	-
CO2	3	3	2	1	-	-	-	-	-	-	2		3	1	-
CO3	3	2	2	1	2	-	-	-	-	-		-	3	1	-
CO4	2	1	1	2	3	-	-	-	-	-	2	-	-	-	1
CO5	3	2	2	2	3	-	-	-	-	-		-	-	2	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Chairs Mcmahon and Jimmie Browne, "CAD / CAM: Principles, Practice and Manufacturing Management", Prentice Hall, 2nd Ed.,1999.

2. Ibrahim Zoid., "CAD / CAM", Theory and Practice, TMH,2001.

3. Radhakrishnan, P., "CAD / CAM / CIM", New Age International,2000

REFERENCE BOOKS:

1. ChandupatlaandBolagundu.,"IntroductiontoFiniteElementMethodsinEngineering",Pearson Education India, 4th Ed., 2015.

2. Mikell P. Groover, "CAD/CAM: Computer-Aided Design and Manufacturing", PHI,2003

3. Newman and Sproull, R.F., "Principles of interactive Computer Graphics",TMH,1997.

Vertical - 8

DIVERSIFIED COURSES

GROUP 2

CURRICULUM

S. No.	Course Code	Course Title	Classification		L	T	P	C
1	AE606801	Boundary layer theory (NPTEL)	PE	Theory	3	0	0	3
2	AE606802	Aero elasticity	PE	Theory	3	0	0	3
3	AE606803	Heat transfer (NPTEL)	PE	Theory	3	0	0	3
4	AE606804	Grid Generation Techniques	PE	Theory	3	0	0	3
5	AE606805	Advanced Vehicle Engineering	PE	Theory	3	0	0	3
6	AE606806	Post Processing in Drone Surveying	PE	Theory	3	0	0	3
7	AE606807	Flexible Manufacturing Systems (Common to MAE, Mech and Aero)	PE	Theory	3	0	0	3
8	MA606203	Aircraft systems and instruments	PE	Theory	3	0	0	3
9	AE606808	MEMS (NPTEL)	PE	Theory	3	0	0	3

AE606801 BOUNDARY LAYER THEORY						
Course Category: Vertical 8	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To acquaint students with the fundamental concepts in boundary layer flow and with the governing equations of viscous flow
- To make students familiarize with obtaining analytical solutions for low speed viscous flow problems commonly found in engineering applications
- To introduce the basic concepts in laminar boundary layer theory and its applications in engineering to students
- To elucidate students on the complex phenomenon in turbulent boundary layer theory and turbulence modelling
- To make students knowledgeable on the techniques used for boundary layer control.

UNIT 1: FUNDAMENTAL EQUATIONS OF VISCOUS FLOW	**9**

Fundamental equations of viscous flow, Conservation of mass, Conservation of Momentum - Navier-Stokes equations, Energy equation, Mathematical character of basic equations, Dimensional parameters in viscous flow, Non - dimensionlisation the basic equations and boundary conditions, vorticity considerations, creeping flow and boundary layer flow.

UNIT 2: SOLUTIONS OF VISCOUS FLOW EQUATIONS	**9**

Solutions of viscous flow equations, Couette flows, Hagen- Poisuelle flow, Flow between rotating concentric cylinders, Combined Couette- Poiseuille Flow between parallel plates, Creeping motion, Stokes solution for an immersed sphere, Development of boundary layer, Displacement thickness, momentum and energy thickness.

UNIT 3: LAMINAR BOUNDARY LAYER	**9**

Laminar boundary layer equations, Flat plate Integral analysis of Karman – Integral analysis of energy equation – Laminar boundary layer equations – boundary layer over a curved body- Flow separation-similarity solutions, Blasius solution for flat-plate flow, Falkner–Skan wedge flows, Boundary layer temperature profiles for constant plate temperature –Reynold's analogy – Pohlhausen method.

UNIT 4: TURBULENT BOUNDARY LAYER	**9**

Turbulence-physical and mathematical description, Two-dimensional turbulent boundary layer equations — Velocity profiles – The law of the wall – The law of the wake – Turbulent flow in pipes and channels – Turbulent boundary layer on a flat plate – Boundary layers with pressure gradient, Eddy Viscosity and mixing length.

UNIT 5: BOUNDARY LAYER CONTROL	**9**

Boundary layer control in laminar flow-Methods of Boundary layer control: Acceleration of the boundary layer-Suction- Injection of a different gas-Prevention of transition - Cooling of the wall - Boundary layer suction- Practical examples of Boundary Layer Control.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Apply fundamental equations of the viscous flow for practical examples.

CO2: Analyze the viscous flow problems for solutions.

CO3: Explain the importance of viscosity and shear flow adjacent to the airframe of the aerospace vehicles.

CO4: Build an understanding about the laminar boundary layer concepts and solution methods.

CO5: Illustration about the importance of turbulence boundary layer in an aerospace Engineering problem.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	2	2	2	-	-	-	-	1	-	2	-	3	3
CO2	3	3	1	2	1	-	-	-	-	1	-	2	-	3	2
CO3	3	2	2	1	2	1	1	-	-	-	1	1	2	2	1
CO4	3	2	1	-	1	-	-	2	-	-	1	1	2	1	1
CO5	3	3	2	1	2	1	-	2	1	1	2	2	2	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. White, F. M., Viscous Fluid Flow, McGraw-Hill Education; 3rd edition, 2005.

2. A.J. Reynolds, "Turbulent flows in Engineering", John Wiley & Sons, 1980.

3. H. Schlichting, "Boundary Layer Theory", McGraw-Hill, New York, 1979.

REFERENCE BOOKS:

1. Frank White – Viscous Fluid flow – McGraw Hill, 1998

2. Ronald L., Panton, "Incompressible fluid flow", John Wiley & Sons, 1984.

3. Tuncer Cebeci and Peter Bradshaw, "Momentum transfer in boundary layers", Hemisphere Publishing Corporation, 1977.

4. Fundamentals of Aerodynamics, John D. Anderson, , McGraw Hill, USA, 2007

WEB RESOURCES:

1. Introduction to boundary layers: https://nptel.ac.in/courses/112106190

AE606802 AERO ELASTICITY						
Course Category: Vertical 8	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

- Explain structural concepts such as elastic stiffness, inertia, influence coefficients, elastic axis, and shear center.
- Describe structural dynamics of wings, including bending and torsion modes of vibration and their associated natural frequencies.
- Apply aeroelastic concepts of divergence, flutter, lift and roll effectiveness, aileron reversal, and mode coalescence.
- Knowledge to formulate and derive static and dynamic aeroelastic equations of motion.
- To Apply Rayleigh-Ritz Method for Approximate continuous aeroelastic systems able to Interpret velocity-damping and velocity-frequency flutter diagrams.

UNIT 1: AERO ELASTICITY PHENOMENA	**9**

Vibration of beams due to coupling between bending and torsion - The aero-elastic triangle of forces - Stability versus response problems – Aeroelasticity in Aircraft Design – Vortex induced vibration – Introduction to aero servo elasticity.

UNIT 2: DIVERGENCE OF A LIFTING SURFACE	**9**

Simple two dimensional idealizations – Strip theory – Fredholm integral equation of the second kind – Exact solutions for simple rectangular wings – Semi rigid assumption and approximate solutions – Generalized coordinates – Successive approximations – Numerical approximations using matrix equations.

UNIT 3: STEADY STATE AEROELASTIC PROBLEMS	**9**

Loss and reversal of aileron control – Critical aileron reversal speed – Aileron efficiency – Semi rigid theory and successive approximations – Lift distributions – Rigid and elastic wings.

UNIT 4: FLUTTER ANALYSIS	**9**

Non-dimensional parameters – Stiffness criteria Dynamic mass balancing – Model experiments – Dimensional similarity – Flutter analysis – Two dimensional thin airfoils in steady incompressible flow – Quasi steady aerodynamic derivatives – Galerkin's method for critical speed – Stability of distributed motion – Torsion flexure flutter – Solution of the flutter determinant – Methods of determining the critical flutter speeds – Flutter prevention and control.

UNIT 5: EXAMPLES OF AEROELASTIC PROBLEMS	**9**

Galloping of transmission lines and flow induced vibrations of tall slender structures and suspension bridges – Aircraft wing flutter- Vibrational problems in Helicopters.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Formulate and perform classical solutions of aeroelastic problems.

CO2: Calculate divergence of a lifting surface in the aerospace vehicles.

CO3: Formulate aeroelastic equations of motion and use them to derive fundamental relations for aeroelastic analysis.

CO4: Analyze the static aeroelastic instabilities such as divergence, control surface reversal and flutter

CO5: Analyze the aeroelastic problems in civil and mechanical engineering.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	-	3	-	-	-	-	-	-	-	-	2	2	-	-
CO2	-	3	-	2	-	-	-	-	2	-	-	-	-	2	1
CO3	2	-	3	-	-	-	-	-	-	-	-	2	2	-	-
CO4	2	-	-	2	3	-	-	-	-	-	-	-	-	-	-
CO5	-	3	-	-	-	-	-	-	-	-	-	-	-	-	

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Fung, Y.C. An Introduction to the theory of Aeroelasticity, Dover Publications Inc., 2008.

2. Bisplinghoff., R.L. Ashley, H., and Halfman, R.L, "Aeroelasticity" Addison Wesley Publishing Co., Inc. II ed. 1996.

3. Broadbent, E.G., Elementary Theory of Aeroelasticity, Bunhill Publications Ltd, 1986.

REFERENCE BOOKS:

1. Blevins R.D, "Flow induced vibrations", Krieger Pub Co; 2 Reprint editions, 2001.

2. Scanlan, R.H. and Rosenbaum, R., Introduction to the Study of Aircraft Vibration and Flutter, Macmillan Co., N.Y., 1991.

WEB RESOURCES:

1.Aeroelasticity - https://nptel.ac.in/courses/101104005

AE606803 HEAT TRANSFER						
Course Category: Vertical 8	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To make students familiarize with the basic methods in Conduction. Understand the concept of Lump Parameter analysis and earn the concepts of boundary layer.
- To elucidate students on the various correlation used in Convective Heat Transfer
- To make students knowledgeable on the Design/size of Heat Exchanger and its types.
- To introduce the concepts of Radiation and laws associated with it, Black Body, Grey Body and View factor.
- To elucidate students on the various technique used for Radiation Exchange and Radiation shielding.

UNIT 1: CONDUCTION	**9**

Introduction to Heat Transfer - Introduction to Heat Transfer - Heat Diffusion Equation - Relevant Boundary Conditions in Conduction - One Dimensional Steady State Conduction - Temperature Distribution in Radial Systems - Tutorial Problem on Critical Insulation Thickness - Heat Source Systems - Tutorial Problems of Heat Generating Systems - Transient Conduction - Lumped Capacitance - Transient heat Conduction - Heisler Chart - Heat Transfer from Extended Surface - Fins and General Conduction Analysis.

UNIT 2: CONVECTION	**9**

Fundamentals of Convection - Equations of Change for Non-isothermal Systems - Equations of Change for Non-isothermal Systems - Application of Energy Equation - Nusselt Number of a heated sphere in Stagnant Air. Momentum and Thermal Boundary Layers - The Flat Plate in Parallel Flow - Hydrodynamics and Momentum Transfer - Flat Plate in Parallel Flow - The Effects of Turbulence - Turbulent External Flow Heat and Momentum Transfer Analogy - Mixed Boundary Layers - Tutorial Problem on External Flow and Behavior of - Heat Transfer Coefficient - Internal Flow Heat Transfer

UNIT 3: HEAT EXCHANGERS	**9**

Free Convection - Heat Exchangers - Tutorial Problems on Heat Exchanger Calculations - Tutorial Problem on LMTD and Dirt Factor - Epsilon-NTU Method - Boiling, Evaporation and Evaporators

UNIT 4: RADIATION	**9**

Fundamental Concepts - Spectral Blackbody Radiation Intesity and Emissive Power Wein's Law - Stephen Boltzmann Law - Blackbody Radiation Function - Kirchhoff's Law- Emissivity - Absroptivity and Blackbody Radiation - Solar Radiation and the Concept of View Factors - Determination of View Factors

UNIT 5: RADIATION EXHANGE	**9**

Radiosity Blackbody Radiation Exchanges, Relevant Problem - Network Method for Radiation Exchange in an Enclosure - Network Method - Two and Three Zone Enclosures - Tutorial Problem on Radiation Exhange using the Network Method Radiation Shields - Gaseous Radiation (Participating Medium)

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Apply the basic methods in Conduction. Understand the concept of Lump Parameter analysis and earn the concepts of boundary layer.

CO2: Apply various correlation used in Convective Heat Transfer

CO3: Design/size Heat Exchanger and its types & laws associated with it.

CO4: Comprehend the concepts of Radiation and laws associated with it, Black Body, Grey Body and View factor.

CO5: Apply various technique used for Radiation Exchange and Radiation shielding.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	3	2	-	-	-	-	-	-	-	-	2	-	-
CO2	3	3	3	2	-	-	-	-	-	-	-	2	-	-	
CO3	3	2	1	2	-	-	-	-	1	1	1	1	2	2	1
CO4	3	2	1	2	1	1	1	-	-	-	-	1	2	-	1
CO5	3	3	3	2	1	1	1	-	1	1	1	1	2	2	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Holman,J.P., "Heat Transfer", McGraw Hill Book Co.,Inc., New York, Sixth Edition,1991.

2. Sachdeva,S.C., "Fundamentals of Engineering Heat and Mass Transfer", Wiley Eastern Ltd., New Delhi,1981.

3. Yunus,A.Cengel, "Heat Transfet-A Practical Approach", Tata McGraw Hill, Second edition, 2003.

4. E Rathakrishnan, "Elements of Heat Transfer", Taylor and Francis, CRC Press, 2012.

REFERENCE BOOKS:

1. Lienhard,J.H., A Heat Transfer Text Book, Prentice Hall Inc., 1981.

2. Mathur,M. and Sharma,R.P., Gas Turbine and Jet and Rocket Propulsion, Standard Publishers, New Delhi, 1988.

3. Sutton,G.P., Rocket Propulsion Elements,John Wiley and Sons, Fifth Edition, 1986

WEB RESOURCES:

1. Heat Transfer: https://nptel.ac.in/courses/103105140

AE606804 GRID GENERATION TECHNIQUES						
Course Category: Vertical 8	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

- To make students understand the need for grid generation for numerical solutions
- To give them exposure to both structured and unstructured grid generation methods
- To impart knowledge on the areas of application and on the implementation methods for structured and unstructured grid generation techniques
- To expose the students on the benefits of adaptive meshing and its methodology
- To impart training to students on the control of grid quality

UNIT 1: BASIC ASPECTS IN GRID GENERATION **9**

Methodology of grid generation- classification of grid generation techniques – Structured, Unstructured and Hybrid grids and their characteristic features – Areas of application –Geometry related issues for grid generation – Grid or mesh topology – Conformal Mapping-Domain decomposition with multiblocking.

UNIT 2: STRUCTURED GRID GENERATION **9**

Algebraic methods for structured grid generation – Use of blending functions for grid generation- Use of partial differential equations for structured grid generation – Elliptic schemes for structured grid generation – Implementation of boundary conditions for smooth grid generation – Variational methods – Applications – A brief introduction to hyperbolic schemes for grid generation.

UNIT 3: UNSTRUCTURED GRID GENERATION **9**

Use of triangular, quadrilateral and tetrahedral grids/meshes – Concept of dual mesh – Connectivity Information and data structure in unstructured grid generation – Hierarchy in unstructured grid Generation – Composite grid schemes in unstructured grid generation – Moving front technique- Delaunay base method – Octree approach.

UNIT 4: ADAPTIVE MESHING **9**

Description of adaptive mesh refinement – Adaption control – Strategies for mesh adaption- Solution gradient based adaption – Discretization error and Recovery based adaption - r adaption, h adaption and p adaption methods – Elementary concepts in dynamic meshing and mesh motion – Role of adaptive meshing in solution accuracy and convergence.

UNIT 5: GRID QUALITY AND QUALITY CONTROL **9**

A brief description of metrics for grid quality – Aspect ratio – Orthogonality – Skewness – Warpage- Jacobian- Best practices for grid quality and grid control – mesh/grid quality aspects in surface meshing – Volume meshing and quality check – Grid quality aspects in boundary layer flows – Prismatic layers –

Quality control in hybrid mesh transition – guideline for checking mesh quality and control.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Acquire knowledge on the basic principles of grid generation and be able to apply preliminary grid selection tasks in aerospace applications

CO2: Understand the multi-block grid generation procedures and be able to evaluate multi-block grid designs of computational domain in aerospace related problems

CO3: Evaluate structured and unstructured grid designs and be able to take decisions on selection of suitable grid blocks for the computational domains in aerospace applications.

CO4: Apply adaptive meshing methods for better management of computer resources and cost effective solutions in aerospace engineering

CO5: Apply skills in ensuring the good quality of grid that is essential to get reasonably accurate numerical solutions for complex aerospace engineering problems

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	2	1	-	-	-	-	-	-	-	-	-	2	-	-
CO2	1	3	-	-	3	-	-	-	-	-	-	-	3	1	-
CO3	1	3	1	1	1	-	-	-	-	-	-	-	3	1	-
CO4	1	2	-	2	3	-	-	-	-	-	-	-	2	-	-
CO5	1	1	1	-	-	-	-	-	-	-	-	-	3	1	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Fletcher C.A.J. , "Computational Techniques for Fluid Dynamics 1" Springer Verlag, 1996.

2. Liseikin V. D., "Grid Generation Methods:, Springer-Verlag Berlin and Heidelberg GmbH & Co. KG 1st edition 1999.

3. Chung T. J., "Computational Fluid Dynamics", Cambridge University Press; 2nd edition, 2010.

REFERENCE BOOKS:

1. Patrick Knupp & Stanly Steinberg, "Fundamentals of Grid Generation" CRC Press 1st edition 1993

2. Versteeg H.K. and Malalsekera W. "An Introduction to Computational Fluid Dynamics, The Finite Volume Method", PHI; 2nd edition 2007.

3. John F Wendt, "Computational Fluid Dynamics – An Introduction", 3rd Edition, Springer- Verlag, Berlin

Heidelberg, 2009.
WEB RESOURCES:
1. Introduction to Grid Generation: http://www.nitttrc.edu.in/nptel/courses/video/112107079/L42.html

AE606805 ADVANCED VEHICLE ENGINEERING						
Course Category: Vertical 8	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To introduce the basic concepts of electric vehicle and their characteristics
- To introduce different types of motors and the selection of motor for vehicle applications.
- To acquaint the student with different sensors and systems used in autonomous and connected vehicles.
- To give an overview of networking with sensors and systems.
- To introduce the modern methods of diagnosing on-board the vehicle troubles.

UNIT 1: ELECTRIC VEHICLES	**9**
EV architectures, advantages and disadvantages, Electrical and mechanical energy storage technologies, battery management. Performance of Electric Vehicles, Tractive effort and Transmission requirement, Vehicle performance, Tractive effort in normal driving.	
UNIT 2: ELECTRIC VEHICLE MOTORS	**9**
Electric Propulsion basics, motor capacity determination, Induction motor, DC motor, Permanent Magnet Motor, Switch Reluctance Motor, Configuration, Characteristics, Performance and control of Drives.	
UNIT 3: AUTONOMOUS AND CONNECTED VEHICLES	**9**
Vehicle-to-Vehicle Technology, Vehicle to Road and Vehicle to Vehicle Infrastructure, Basic Control System, Surroundings Sensing Systems, Role of Wireless Data Networks, Advanced Driver Assistance Systems, Basics of Radar System, Ultrasonic Sonar Systems, Lidar System, Camera Technology, Basics of Wireless Technology, Receiver System.	
UNIT 4: AUTOMOTIVE NETWORKING	**9**
Bus Systems – Classification, Applications in the vehicle, Coupling of networks, networked vehicles, Buses - CAN Bus, LIN Bus, MOST Bus, Bluetooth, Flex Ray, Diagnostic Interfaces	
UNIT 5: ON-BOARD TESTING	**9**
Integration of Sensor Data to On-Board Control Systems (OBD), OBD requirements, certification, enforcement, systems, testing, Catalytic converter and Exhaust Gas Recirculation system monitoring,	

Introduction to Cyber-physical system

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Acquire an overview of electric vehicles and their importance in automotive.

CO2. Discuss the characteristics and the selection of traction motor.

CO3. Comprehend the vehicle-to-vehicle and autonomous technology.

CO4. Explain the networking of various modules in automotive systems, communication protocols and diagnostics of the sub systems.

CO5. Be familiar with on-board diagnostics systems.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO2	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO3	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO4	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1
CO5	2	1	1	1	-	-	2	-	1	-	-	1	1	2	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. John G Hayes and G AbaasGoodarzi, Electric Powertrain -, 1st Edition, John Wiley & Sons Ltd., 2018.

2. Hussain T Mouftah, Melike Erol-kantarci and Samesh Sorour, Connected and Autonomous Vehicles in Smart Cities,CRC Press, 1st Edition, 2020.

3. Advanced Technology Vehicles Manufacturing (ATVM) Loan Program (Energy Science, Engineering and Technology: Congressional Policies, Practices and Procedures)by Andrew M Wright and Harrison R Scott | 5 September 2012.

REFERENCE BOOKS:

1. Dominique Paret, Multiplexed Networks for Embedded Systems, John Wiley & Sons Ltd., 2007.

2. Hong Cheng, ―Autonomous Intelligent Vehicles: Theory, Algorithms & Implementation‖, Springer, 2011.

3. Advanced Vehicle Technology by Heinz Heisler MSc BSc FIMI MIRTE MCIT | 17 July 2002
148.

4. Advanced Motorsport Engineering: Units for Study at Level 3by Andrew Livesey | 1 September 2011.

WEB RESOURCES:

1. Fundamentals of Electric vehicles:https://nptel.ac.in/courses/108106170

AE606806 POST PROCESSING IN DRONE SURVEYING						
Course Category: Vertical 8	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To introduce the basic concepts of Agisoft Metashape Pro, Photogrammetry Software.
- To introduce Data Geo Referencing With RTK, PPK or RPK Methods.
- To acquaint the student with Global Mapper, GIS Software.
- To give an overview of Pythagoras CAD And GIS.
- To introduce the concepts of UAV Data Processing.

UNIT 1: AGISOFT METASHAPE PRO, PHOTOGRAMMETRY SOFTWARE	**9**

PhotoScan – application available in Standard and Pro versions- automatic generation- classifiable dense point clouds- textured polygon models (3D model)- geo-referenced orthomosaics-DSM-Digital Surface Models (DEM-Digital Elevation Model)- Digital Terrain Models (DTM)**.**

UNIT 2: DATA GEO REFERENCING WITH RTK, PPK OR RPK METHOD	**9**

position and orientation system (POS) data-Ground control points (GCPS)- Google Earth coordinates-metric accuracy-automatic mode based on the positioning metadata-PPK (Post Processed Kinematics)- RPK (Re-processed Kinematics)- GeotagZ software from Septentrio-GNSS reception base-Septentrio Altus-NR3-RINEX data-fixed base in real time (via NTRIP) or in PPK.

UNIT 3: GLOBAL MAPPER, GIS SOFTWARE	**9**

Stand-alone spatial data management software-Topographs-points clouds, orthophotos or DSM/DTM-Blue Marble Geographics-Global Mapper, LIDAR module and GeoCalc-accurate map creation-optimized spatial data management-powerful analytics tools-Terrain Analysis and 3D Data Processing-Raster and vector creation and editing features-intuitive drawing to image correction and vectorization-Advanced Attribute Editing and Real-Time Hill Shade Rendering.

UNIT 4: PYTHAGORAS CAD AND GIS	**9**

Mapping solution for all your geodata- 360° compatible-Land Surveying- drawing and calculation tools-Agriculture- Soils analysis, crop monitoring, irrigation and growth management, damage detection and creating machine control- GPS data and UAV images allows to create 3D models- Mining- 3D models, excavation reports, contour lines, profiles and cross sections.

UNIT 5: UAV DATA PROCESSING	**9**

Orthomosaic Maps- 3D Point Cloud- Digital Surface Models (DSM)- Digital Terrain Models (DTM)- Contour Maps-3D textured mesh

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Acquire an overview of Agisoft Metashape Pro, Photogrammetry Software.

CO2. Apply RTK, PPK or RPK Methods for Data Geo Referencing.

CO3. Apply the concepts of Global Mapper, GIS Software.

CO4. Apply the concepts of Pythagoras CAD And GIS to solve drone survey problems.

CO5. Analysis the UAV data using Digital Surface Models, Digital Terrain Models.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	1	1	1	2	-	-	-	1	-	-	1	1	1	1
CO2	1	1	1	1	2	-	-	-	1	-	-	1	1	1	1
CO3	1	1	1	1	2	-	-	-	1	-	-	1	1	1	1
CO4	1	1	1	1	2	-	-	-	1	-	-	1	1	1	1
CO5	1	1	1	1	2	-	-	-	1	-	-	1	1	1	1

1- low, 2 - medium, 3 - high, '-' no correlation

REFERENCE BOOKS:

1. Garvit Pandya, Basics of Unmanned Aerial Vehicles: Time to start working on Drone Technology, Notion Press, 2021.

2. PK Garg, Introduction To Unmanned Aerial Vehicles, New Age International Publishers New Age International Private Limited; First edition (1 October 2020).

3. Kike Calvo, So You Want to Create Maps Using Drones?, Blurb Publishers, 2015.

WEB RESOURCES:

1. The Ultimate Guide for Land Surveying with Drones: https://www.udemy.com/course/land-surveying-with-drones-fly-process-analyze-1/

AE606807 FLEXIBLE MANUFACTURING SYSTEMS (Common to MAE, Mech and Aero)						
Course Category: Vertical 8	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

1. To impart knowledge about FMS & its applications.
2. To impart knowledge about Measuring cell.
3. To impart knowledge about Group Technology
4. Differentiate Turning & Machining Centres.
5. To impart knowledge about CMM.

UNIT 1: FMS INTRODUCTION AND DESCRIPTION	**9**
Limitations with conventional manufacturing, Need for FMS Introduction, Definition, Basic Component of FMS, Significance of FMS, Benefits and limitations of FMS, Area of Application of a FMS in Industry, Various Hardware and Software required for an FMS, CIM Technology,	
UNIT 2: MANUFACTURING CELL	**9**
Introduction, Description and Classifications of Cell, Unattended Machining, Cellular versus Flexible Manufacturing, General layout and configuration of FMS, Principle Objectives of FMS, Hierarchy of CIM, FMS Justification.	
UNIT 3: GROUP TECHNOLOGY	**9**
Introduction, Definition, Reasons for Adopting Group Technology, Benefits of Group Technology Affecting Many Areas of a Company, Obstacles to Application of GT	
UNIT 4: TURNING AND MACHINING CENTRES	**9**
Introduction, Types, Construction and Operation Performed on Turning enter, Automated Features and Capabilities of Turning Centres, Pallet and Part Loading and Programming Options in Machining Centres.	
UNIT 5: COORDINATE MEASURING MACHINES	**9**
Introduction, Types, Construction and General Functions of CMM, Operational Cycle Description, CMM Applications, Importance to Flexible Cells and Systems.	
TOTAL: 45 PERIODS	

COURSE OUTCOMES: At the end of the course, the student will be able to
CO1: Demonstrate the ability to design a various system using pneumatic and hydraulic components.
CO2: Keep abreast knowledge on various flight control system and its recent advancements.
CO3: Demonstrate the fundamental understanding of the operation of engine auxiliary systems.
CO4: To understand the various cabin comfort system used in aircraft modern display systems.
CO5: Describe the principle behind the operation of various vital parameter displays and its uses

in effective conduct of the flight.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	-	-	-	-	-	-	-	-	-	-	-	2	1	-
CO2	3	2	3	2	3	-	-	-	-	-	2	-	2	1	-
CO3	3	2	3	2	3	-	-	-	-	-	3	-	2	1	-
CO4	3	2	3	2	3	-	-	-	-	-	3	-	2	1	-
CO5	3	2	3	2	2	-	-	-	-	-	3	-	2	1	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Shivanand H.K., Benal MM, Koti V, "Flexible Manufacturing System", New age international (P) Limited, New Delhi, 2006

2. Mikell P. Groover "Automation, Production Systems and Computer Integrated Manufacturing", PHI, 2008

REFERENCE BOOKS:

1. Approach to Computer Integrated Design and Manufacturing Nanua Singh, John Wiley and Sons, 1998

2. Kalpakjin, "Manufacturing Engineering and Technology ", Addison-Wesley Publishing Co., 1995.

WEB RESOURCES:

1. https://archive.nptel.ac.in/courses/110/106/110106044/

AE606808 AIRCRAFT SYSTEMS AND INSTRUMENTS						
Course Category: Vertical 8	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To impart knowledge of the hydraulic and pneumatic systems components
- To Study the types of instruments and its operation including navigational instruments.
- Acquire the knowledge of essential systems of safe aircraft operation.
- To learn the concepts of display systems
- To study the various engine systems in aircraft

UNIT 1: AIRCRAFT SYSTEMS	**9**

Hydraulic systems – Study of typical systems – components – Hydraulic systems controllers – Modes of operation – Pneumatic systems – Working principles – Typical Pneumatic Power system – Brake system – Components, Landing Gear Systems – Classification – Shock absorbers – Retractive mechanism.

UNIT 2: AIRPLANE CONTROL SYSTEMS	**9**

Conventional Systems – Power assisted and fully powered flight controls – Power actuated systems – Engine control systems – Push pull rod system – operating principles – Modern control systems – Digital fly by wire systems – Auto pilot system.

UNIT 3: ENGINE SYSTEMS	**9**

Piston and Jet Engines- Fuel systems – Components - Multi-engine fuel systems, lubricating systems – Starting and Ignition systems.

UNIT 4: AIRCONDITIONING AND PRESSURIZING SYSTEM	**9**

Basic Air Cycle systems – Vapour Cycle Systems, Boot-strap air cycle system – Evaporative vapour cycle systems – Evaporation air cycle systems – Oxygen systems – Fire extinguishing system and smoke detection system, Deicing and anti-icing system.

UNIT 5: AIRCRAFT INSTRUMENTS	**9**

Flight Instruments and Navigation Instruments – Accelerometers, Air speed Indicators – Mach Meters – Altimeters - Gyroscopic Instruments– Principles and operation – Study of various types of engine instruments – Tachometers – Temperature and Pressure gauges.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Demonstrate the ability to design a various system using pneumatic and hydraulic components.

CO2: Keep abreast knowledge on various flight control system and its recent advancements.

CO3: Demonstrate the fundamental understanding of the operation of engine auxiliary systems.

CO4: To understand the various cabin comfort system used in aircraft modern display systems.

CO5: Describe the principle behind the operation of various vital parameter displays and its uses in effective conduct of the flight.

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	-	-	-	-	-	-	-	-	-	-	-	2	1	-
CO2	1	2	2	2	2	-	-	-	-	-	1	-	2	1	-
CO3	1	2	2	2	2	-	-	-	-	-	1	-	2	1	-
CO4	1	2	2	2	2	-	-	-	-	-	1	-	2	1	-
CO5	1	2	2	2	2	-	-	-	-	-	1	-	2	1	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Mekinley, J.L. and R.D. Bent, Aircraft Power Plants, McGraw Hill, 1993.

2. Pallet, E.H.J. Aircraft Instruments & Principles, Pitman & Co, 1993.

3. Handbooks of Airframe and Power plant Mechanics, US dept. of Transportation, Federal, Aviation Administration, the English Book Store, New Delhi, 1995.

REFERENCE BOOKS:

1. McKinley, J.L. and Bent R.D. Aircraft Maintenance & Repair, McGraw Hill, 1993.

2. Teager, S, "Aircraft Gas Turbine technology, McGraw Hill 1997.

WEB RESOURCES:

1. Aircraft Maintenance: https://nptel.ac.in/courses/101104071

AE606809 MEMS						
Course Category: Vertical 8	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To introduce the concepts of micro electromechanical devices
- To educate on the rudiments of Micro fabrication techniques
- To introduce the design concepts of micro sensors
- To know the design concepts of micro actuators
- To educate on the applications of MEMS to various disciplines

UNIT 1: INTRODUCTION TO MEMS	**9**
Introduction to MEMS, Overview of Micro electro mechanical Systems, Materials for MEMS: Silicon, silicon compounds, polymers, metals.	
UNIT 2: MEMS FABRICATION TECHNOLOGIES	**9**
Photolithography, Ion Implantation, Diffusion, Oxidation, CVD, Sputtering Etching techniques, Micromachining: Bulk Micromachining, Surface Micromachining, LIGA.	
UNIT 3: MICRO SENSORS	**9**
MEMS Sensors: Design of Acoustic wave sensors, Vibratory gyroscope, Capacitive Pressure sensors, Case study: Piezoelectric energy harvester.	
UNIT 4: MICRO ACTUATORS	**9**
Design of Actuators: Actuation using thermal forces, Actuation using shape memory Alloys, Actuation using piezoelectric crystals, Actuation using Electrostatic forces, Case Study:RF Switch.	
UNIT 5: APPLICATIONS OF MEMS	**9**
MEMS for Space Application, Polymer MEMS & Carbon Nano Tubes CNT, Wafer Bonding & Packaging of MEMS, Interface Electronics for MEMS, MEMS for Biomedical Applications (Bio-MEMS).	
TOTAL: 45 PERIODS	

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Interpret the basics of micro electromechanical systems including their applications and advantages

CO2: Recognize the use of materials in micro fabrication and describe the fabrication processes including surface micromachining, bulk micromachining and LIGA.

CO3: Comprehend the design concepts of micro sensors.

CO4: Analyze the key performance aspects of electromechanical transducers including actuators

CO5: Apply MEMS to various disciplines

CO'S PO'S&PSO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO2	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-
CO3	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-
CO4	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-
CO5	1	2	2	2	2	-	-	-	-	-	1	-	1	-	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Chang Liu, 'Foundations of MEMS', Pearson Education Inc., 2012.

2. Stephen D Senturia, 'Microsystem Design', Springer Publication, 2000.

3. Tai Ran Hsu, "MEMS & Micro systems Design and Manufacture" Tata McGraw Hill, New Delhi, 2002.

REFERENCE BOOKS:

1. Marc Madou, ―Fundamentals of Microfabrication‖, CRC press 1997.

2. Sergey Edward Lyshevski, ―MEMS and NEMS: Systems, Devices, and Structures‖ CRC Press, 2002

3. Nadim Maluf," An Introduction to Micro Electro Mechanical System Design", Artech House, 2000.

WEB RESOURCES:

1. MEMS and Microsystems: https://nptel.ac.in/courses/117105082